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McNAIR SCHOLARS PROGRAM

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McNair
Scholars Program

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About the University of North Georgia McNair Journal,

The first issue of the University of North Georgia (UNG) McNair Journal presents the findings of undergraduate research conducted by the University of North Georgia Ronald E. McNair Post Baccalaureate Achievement Program Scholars who graduated Spring 2020, Fall 2020 and Spring 2021. All research was conducted under the supervision of University of North Georgia faculty who served and volunteered as Faculty Research Mentors. The hard work and persistence required in producing new knowledge through research is evident in these articles. Since 2017, the UNG McNair Scholars Program has enhanced the lives of students. McNair is a valued diversity and inclusion program which provides educational access and opportunity for program eligible students who express a strong desire to continue to graduate education to pursue and achieve a doctoral degree. The professional staff of the UNG Ronald E. McNair Post Baccalaureate Achievement Program thank the following University leaders for their ongoing support: Dr. Bonita Jacobs, President of UNG, Dr. Chaudron Gille, Provost and Senior Vice President of Academic Affairs and Andy Novobilski, Associate Provost/Chief Research Officer.

The Ronald E. McNair Postbaccalaureate Achievement Program at University of North Georgia is a federal TRIO program funded by the U.S. Department of Education.

Cover Design by : Julianne "Jules" Reynolds, Academic Coordinator

TRIO
RONALD E. MCNAIR
POST-BACCALAUREATE
ACHIEVEMENT PROGRAM

In 1989, Congress created the Ronald E. McNair Post baccalaureate Achievement Program to assist low-income/first-generation and underrepresented minority students in the pursuit of graduate education. McNair programs are housed at 187 Universities in the U.S. Five of these programs are in Georgia.

The McNair program is funded by the U.S. Department of Education as one of the federal government's TRIO programs, this program prepares undergraduates students for pursuit of a doctoral degree by providing financial support, mentoring and opportunities so they can gain research experience, academic skills and strategies, and develop student/faculty mentor relationships that are so crucial for success in higher education.

Dr. Ronald E. McNair was born in Lake City, South Carolina on October 21, 1950. He died in the Space Shuttle Challenger accident on January 28, 1986.

Dr. McNair received a Bachelor of Science degree in engineering physics, magna cum laude, from the North Carolina Agricultural and Technical State University in Greensboro, North Carolina in 1971.

In 1976, he received a Ph.D. degree in Physics from the Massachusetts Institute of Technology. After graduation from MIT, he became a staff physicist at the Hughes Research Lab in Malibu, California.

Dr. McNair then joined NASA in 1978 as a candidate astronaut. During Dr. McNair eight years at NASA he logged over 191 hours in space.

That fateful day January 28, 1986, the Space Shuttle Challenger explosion took the lives of Dr. McNair, and six other crewmen: Mr. F. R. Scobee, Commander M. J. Smith (USN), Lieutenant Colonel E. S. Onizuka (USAF), Dr. J. A. Resnik, Mr. G. B. Jarvis, and Mrs. S. C. McAuliffe.

Ronald E. McNair Post-baccalaureate Achievement Program:

The McNair Scholars Program is a federal TRIO program funded at 151 institutions across the United States and Puerto Rico by the U.S. Department of Education. It is designed to prepare undergraduate students for doctoral studies through involvement in research and other scholarly activities. McNair participants are either first-generation college students with financial need, or members of a group that is traditionally underrepresented in graduate education and have demonstrated strong academic potential. The goal of the McNair Scholars Program is to increase graduate degree awards for students from underrepresented segments of society.

Greetings scholars!

I want to start off by saying how incredibly proud of you we all are. The past year was unprecedented and tested our resolve and our grit and stressed us all in ways we weren't expecting. With everything that was going on in the national stage it was easy to recede and pull away from our research, especially so for those of us who had to pause on campus activities. While these derailments had the chance to devastate our students, all of you persevered!

As we begin 2021 I wanted to express to everyone how excited I am to see our 4th spring graduating class go on to change the world for the better. I know sometimes it's hard to see how your research and work impacts the larger scale but please understand that our world needs scholars like yourselves to bring your perspectives and experiences to industry and academia alike.

First generation students make up just 30% of all doctorates awarded each year, while Blacks and Latino students make up approximately 7%. While these numbers may not seem large they are both consistently rising year by year. By working toward the next step you are joining a prestigious and growing group of academically minded researchers! What's more is you are helping us shape an even better program for those that come after you. As we grow we hope to provide excellent mentorship and advice while maintaining the highest degree of rigor and motivation for our scholars. I look forward to this New Year and the possibilities it provides for our graduating seniors and our up and coming scholars alike. Remember that whenever it gets tough, you have the full support of our team and your mentor at your back!

Never stop growing!

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The Exploration of Multiple Stressors Affecting Anxiety and Depression in College Students

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ABSTRACT

There are a multitude of factors that affect college students' mental health and well-being. Students often endure many obstacles that can severely hinder their ability to function and succeed throughout their academic career. According to Andrews and Wilding's (2004) study, among UK students who exhibited no psychological symptoms before college, 9% were diagnosed with depression, and 20% were diagnosed with generalized anxiety disorder halfway through their college career. Furthermore, many students are unaware of the resources available within their institution that are designed to help minimize their levels of stress and anxiety. Without this knowledge and awareness, students' symptoms are often exacerbated. In this study, an examination of multiple academic and non-academic stressors on depression and anxiety in college students was conducted. We replicated McIntyre et al.'s (2018) research, measuring several predictors of anxiety and depression: financial worry, academic stress and performance, work status, student involvement, loneliness, and social support. In addition to these factors, we also assessed students' counseling attendance and their response to the COVID-19 pandemic. Participants completed a 52-item questionnaire administered through Qualtrics, an online survey software program. Results indicate that students' academic stress, own expectations, loneliness, social support, and test anxiety, explain a significant proportion of levels of depression and anxiety. Furthermore, both depression and anxiety are correlated to one another. The purpose of this study is to understand the multiple stressors that college students endure and how counseling affects their ability to cope with these stressors.

Keywords: multiple stressors, counseling, depression, anxiety

Mental health is a frequent topic of interest among college students, as this population often endures intense pressure and expectations from themselves, parents, and professors. The lifetime prevalence of depression and anxiety in young female and male adults is progressively increasing, with a total of 18% of youth exhibiting depressive symptoms (Saeed et al., 2018). There are a multitude of factors that contribute to both depression and anxiety symptoms in college students. The obstacles that college students must endure leave many feeling drained of their energy, and they often find themselves struggling with feelings of depression and anxiety. Rankin, Paisley, Mulla, & Tomeny (2018) note that the transition from high school to college has been shown to significantly increase symptoms of anxiety and depression, as students are faced with many new obstacles and often do not have their parents nearby to help them cope with those obstacles. Other stressors that seem to affect symptoms of depression and anxiety in students are perceived social support, academic stressors, and loneliness. Rankin et al. (2018) suggests that adequate social support has been linked to a decrease in symptoms in depression and anxiety, as well as the utilization of positive coping skills and increased psychological adjustment to chronic health conditions. In McIntyre et al.'s (2018) study, researchers found that academic stressors, specifically relative performance and assessment stress, were associated with increased levels of depression. As noted, there are many factors that can affect one's psychological well-being. Throughout this review of past literature relating to depression and anxiety in college students, an in-depth analysis of academic and non-academic predictors of depression and anxiety will be conducted.

LITERATURE REVIEW

Mental health issues have long been stigmatized in society and have lacked the attention needed in order to create positive change in the psychological well-being of those who endure these issues. It has progressively become a more recognized topic, especially for college students who are exposed to a multitude of stressors on a daily basis. McIntyre et al. (2018) researched on how attending post-secondary education affects the mental health of students. The researchers designed their study in hopes of being able to provide information on the effects caused by academic and non-academic stressors on mental health. They also were interested in investigating how social relationships can act as a mediator between psychological well-being and stressors. A review of 40 studies found that the most common predictor of stress that most college students endure is relationship stress, such as family, romantic, peer, and faculty relationships. Another source of stress reported by students was their own expectations they held for themselves, others' expectations (such as their parents), and the lack of available resources they need to succeed in college (i.e. sleep, time, and money). More evidence was found that when students attend higher education, their psychological well-being will be both negatively and positively impacted. These results are shown in Andrews and Wilding's (2004) study in which they found that a significant proportion of students who did not exhibit

symptoms of depression or generalized anxiety disorder before entering college were diagnosed with these disorders after attending college for about two years. In McIntyre et al.'s (2018) research, they created an online survey available for students attending a large university in northern England, with a total of 1545 students completing the survey. In this survey, they measured several factors including academic stress, expectation stress (expectations from themselves and from teachers and parents), relative performance, loneliness, social identity (the extent to which they feel they belong to a group), living conditions, financial worry, perceived discrimination, cyber victimization, childhood disadvantage and maltreatment, paranoia, depression, anxiety, and self-harm. Overall, McIntyre et al. (2018) found that many students seemed to be experiencing high levels of mental distress. Across the board, 21% of students were experiencing high levels of anxiety, 11% of students were experiencing depressive symptoms, and 9% were experiencing high levels of both disorders. Additionally, suicidal ideation was experienced by one-fifth of the students surveyed, and 2% of students had previously attempted suicide. Other factors contributing to poor mental health were childhood adversity, economic deprivation, discrimination, and loneliness. Both assessment stress and relative performance stress were the two most significant academic predictors of psychological distress. Poor mental health was most significantly predicted by loneliness, exemplifying that having social support at school can help protect students from experiencing feelings of loneliness, depression, and other psychological disorders. McIntyre et al.'s (2018) research exemplifies why studying mental health in college students is so important. Symptoms of depression and anxiety are affected by an array of stressors that most students must endure. For the study explained in this paper, we have replicated McIntyre et al.'s (2018) research to measure symptoms of depression and anxiety in students at the University of North Georgia, with the inclusion of additional research questions concerning counseling attendance and response to the COVID-19 pandemic.

Anxiety

Anxiety has been shown to be affected by academic stress in past studies concerning university students. The pressure to succeed and maintain good grades has been listed among the top of university student concerns (Beiter et al., 2015). Using the Academic Stress Scale (Kohn & Frazer, 1986), researchers discovered that assessment stress has been found to be a significant predictor or anxiety in college students (Mcintrye et al., 2018). When comparing causes of anxiety among college students, academic stress accounted for the greatest variance of anxiety when compared to financial stress and family and peer support (Jones et al., 2017).The present study seeks to find academic stress as a predictor of anxiety. Greater academic stress has been found to be related to greater anxiety, therefore we hypothesize that there will be a positive correlation between academic stress and anxiety among university students.

Depression and Academic Performance

Symptoms of depression can significantly affect one's ability to perform academically. Deroma, Leach, and Leverett (2009) measured the effects of depression on academic performance by administering the Beck Depression Inventory-II (BDI-II; Beck et al., 1996) to a sample of 164 psychology students (65% men and 35% women) attending a military college in the Southeast. The purpose of their study was to identify students' severity of depressive symptoms and how those symptoms correlate to their cumulative grade point average (GPA). Researchers chose to organize the severity of symptoms of depression as four distinct categories: normal and minimally depressed, 0-13; mildly depressed, 14-19; moderately depressed, 20-28; severely depressed, 29-63 (Beck et al., 1996). Students self-reported their GPA as part of their demographic information. Overall, Deroma et al. (2009) found a significant negative correlation between students' self-reported GPA and the severity of depression they were experiencing. Those who were experiencing moderate levels of depressive symptoms had substantially lower GPAs than those who exhibited mild to minimal levels of depression. Although higher severity of depressive symptoms did not necessarily indicate a lower GPA. Students who exhibited severe depressive symptoms did not have lower GPAs than those who had mild to moderate depressive symptoms. This result could be due to the perfectionist tendencies that many college students seem to possess. These tendencies lead students to try and obtain unrealistic goals, which negatively impacts depressive symptoms but positively impacts GPA. The directional relationship between the two factors is unclear. There is not significant evidence suggesting that one factor causes the other. Because the relationship is unclear, we cannot assume that symptoms of depression affect academic performance, but academic performance does not affect symptoms of depression. Furthermore, there are many other forms of measurement of academic performance that were not considered, as the main variable investigated in this study was GPA. This leads us as researchers to investigate other facets of academic performance, such as parent/teacher expectations and test anxiety, along with GPA. Analyzing these factors could give us a clearer understanding of the direction of the relationship between academic performance and depression, as well as allow us to identify what facets of academic performance are affected most by depressive symptoms in college students.

Financial Worry

Financial worry has been known to show strong effects on the mental health of college students. In a longitudinal, cross sectional study, students who had greater financial stress predicted greater depression, anxiety, stress, and alcohol dependence (Richardson et al., 2016). Students who are struggling with financial difficulties are also more likely to be aware that they need mental health support yet are less likely to seek it out than students with fewer financial difficulties (Nash et al., 2017). There is an obvious gap between students with financial difficulties compared to students with fewer financial worries, which is a discrepancy that needs to be addressed among college campuses in order to increase mental health support. Financial worry can also affect students' involvement on campus. Students who are not able to participate in the same activities as their peers have higher financial stress than students who are participating in extracurricular college activities (Montalto et al., 2016). Students who have high financial worry are also less likely to participate in Student Support Services and have lower retention and graduation rates than students with low financial stress (Adams et al., 2016). Having financial stability is one of the most significant components that contributes to a person's overall well-being according to previous literature; Therefore, students need financial instruction and support in order to reduce financial stress and possess a positive overall well-being (Gutter et al., 2011). A national survey also showed that freshmen are more likely to have higher financial well-being than upperclassmen, possibly due to the increasing responsibility freshman have when leaving home and desire to be socially connected (Gutter et al., 2011). We hypothesize that students with greater financial worry are less likely to be involved in campus activities.

Having financial support from parents or guardians has been shown to significantly reduce financial stress and the negative impacts that financial stress can have on students' mental health. Watson, Barber, and Dziurawiec (2016) researched the effects of living at home with parents, as well as students' perceived adequacy of financial support from their parents. The researchers' main goal was to determine how students were affected emotionally and financially based on their place of residency and financial support received from their parents. The results found exemplify that financial burdens do play a significant role in students' ability to cope with stress. Students who lived away from home, as well as received minimal financial support from their family reported more frugal spending habits than all other groups. They also exemplified significant financial and psychological strain compared to the other groups. Overall, the results showed that students' perceived financial support from parents significantly impacts, and can act as a buffer, to mental illness in college students. We hypothesize that perceived financial support will have a significant positive effect on mental health in college students.

Student Involvement and Academic Performance

A protective factor that aids students in their academic success, as well as reduces their risk of experiencing anxiety and depression, is involvement in co-curricular programs on campus. Bergen-Cico and Viscomi (2012) explored the link between students' attendance at co-curricular programs available on campus and their GPA. According to the researchers, learning retention and academic success are positively correlated with experiences outside the classroom, as well as course-based learning. The researchers further expanded on this idea, which led them to conduct research on the academic value (in terms of calculated GPA) of co-curricular programs available to students. Speakers, musicians, theatrical productions, student sponsored entertainment, and dances are some examples of the co-curricular programs that were available to students. Participants chosen for the study were first-year students attending a large four-year college in the Northeast. Two cohorts (Fall 2002 & Fall 2003) were chosen and followed over the course of eight semesters. Bergen-Cico and Viscomi gathered data on students' attendance at co-curricular activities by keeping track of their ID numbers on the hand-held magnetic strip readers used to scan student ID cards. Using these ID numbers, researchers were able to pull information such as gender, academic year, cumulative GPA, and current GPA from students' records. Students' records of event attendance were broken down into two clusters: low-level (attending 4 or fewer events) and mid-level (attending 5-14 events). Results indicated that co-curricular attendance is positively correlated with GPA. Programs that exhibited higher student engagement were the ones that possessed faculty members who encouraged student involvement outside of the classroom. While there are patterns of relationship found between student involvement and academic performance, there are other factors within academic performance that need to be investigated. We include these factors in our study because they may also be related to mental health among college students. Students who are involved in fewer extracurricular activities may experience greater loneliness and mental health issues. Since GPA is negatively correlated with depression (Deroma et al., 2009), and student involvement is positively correlated with GPA, we hypothesize that students with lower involvement campus will have a lower GPA and greater scores in anxiety and depression.

Involvement on Campus

Loneliness is another significant factor that affects student health and well-being, considering it leads to higher levels of anxiety and depression (McIntryre et al., 2018). When students make the decision to go to college, they also make the important choice of whether to live on campus or off campus. Living with a roommate allows for close attachments and relationships and can be beneficial for students (Sandford & Rowatt, 2004). This closeness leads to greater social support, and students with roommates reported lower levels of loneliness than students without roommates (Henniger et al., 2016). Similarly, students had lower levels of loneliness when they reported having high levels of social support from friends and significant others (Henniger et al., 2016). Students who live on campus also have easy access to campus events and organizations. Students who live off campus are less likely to be involved than students who live on campus (Jackson et al., 2011). A study has not yet been done measuring the effects of social support with loneliness on factors such as student involvement and campus residency. We hypothesize that students who live on campus will be more involved and therefore have lower levels of loneliness compared to students who live off campus.

The current study seeks to find factors influencing the psychological well-being of college students. We hypothesize the following:

1. A relationship between depression and academic performance
2. That there will be a positive correlation between academic stress and anxiety among university students
3. Students with greater financial worry are less likely to be involved in on campus activities.
4. Perceived financial support will have a significant effect on mental health in college students
5. Students with lower involvement campus will have a lower GPA and greater scores in anxiety and depression
6. Students who live on campus will be more involved and therefore have lower levels of loneliness compared to students who live off campus

METHOD

Participants

A 52-item survey was administered to 334 students using Qualtrics Survey Software. 324 (232 freshmen, 59 sophomores, 28 juniors, 11 seniors) students fully completed the survey. Participation in the study was completely voluntary, and students were awarded one hour of research credit for participating.

Materials

The survey included a mix of both Likert scale and open-ended questions. The first block of the survey contained the consent form, which explained the purpose of the study and provided resources for students to seek out if they experienced distress while taking the survey. Due to the sensitive nature of the questions and their potential to create psychological distress, we also included several blocks throughout the survey that contained the resource information. In the second survey block, we included demographic questions to help us accurately describe our participant pool. We also included counseling questions evaluating the frequency of students who have seen or are currently seeing a counselor. The scales implemented in the survey were obtained through McIntyre et al.'s (2018) research study, and we also used our own novel research items to assess counseling attendance and responses to COVID-19.

Anxiety Scale

For measures of anxiety, students completed Spitzer et al.'s (2006) Generalized Anxiety Disorder-7 (GAD-7) scale (α = .928). Within this measure, students indicated their level of anxiety using a 4-point Likert scale (from 0 = "not at all" to 3 = "nearly every day"). The scale included questions such as "Over the last two weeks, how often have you been bothered by feeling nervous, anxious or on edge?" and " Over the last two weeks, how often have you been bothered by worrying too much about different things?" in order to measure students' level of anxiety. Students indicated the frequency in which they endured these problems using the Likert scale provided.

Depression Scale

Students indicated their level of depressive symptoms by completing Kroenke et al.'s (2013) Patient Health Questionnaire-9 (PHQ-9) using a 4-point Likert scale (from 0 = "not at all" to 3 = "nearly every day") (α = .921). The scale included questions such as "Over the last two weeks, how often have you been bothered by feeling bad about yourself-or that you are a failure or have let yourself or your family down?" and "Over the last two weeks, how often have you been bothered by thoughts that you would be better off dead or of hurting yourself in some way?" in order to measure students' depressive symptoms. Students indicated their depressive symptoms using the Likert scale provided.

Financial Worry Scale

Financial worry was assessed using Cook et al.'s (2004) 2-item Financial Worry Scale. Students were asked, "Are financial concerns a current issue?" and "To what extent does your debt worry you?". Participants indicated their level of financial worry on a 5-point Likert scale (1 = "not at all" to 5 = "a lot").

Loneliness Scale

To measure feelings of loneliness, we implemented Hays and DiMatteo's (1987) UCLA Loneliness Scale-8 (ULS-8) in which participants indicated on a 4-point Likert scale (1 = "never" to 4 = "often") how often they experienced loneliness (α = .854). Student involvement was measured using our own novel research questions, asking students, "Are you involved on campus? If yes, what kind of things are you involved in? (Select all that apply)" with several choices to select from, including "I am not involved on campus", "Fraternity/sorority", "Religious organization", "Club", "Club sports", and "Other (please list below)" and "Do you feel like you belong to a social group on campus?". Attachments of the consent form, demographics questions, counseling questions, and scales are included in the appendices.

Design

The design of this study was non-experimental and a combination of significance and correlational testing was used. The variables in this study were dependent on the constructs we were measuring. We conducted a multiple regression analysis to measure general predictors of anxiety/depression, with anxiety and depression being the dependent variables and financial worry, academic stress and performance, work status, student involvement, loneliness, questions regarding COVID-19, and social support as independent variables. When measuring financial worry as a predictor, we used an independent t-test, with financial worry as the dependent variable and student counseling attendance, hours worked per week, housing situation and involvement as independent variables. We used a linear regression when measuring loneliness as a predictor for depression and anxiety, with loneliness being the independent variable, and community involvement, depression, and anxiety being dependent variables. When measuring student involvement as a predictor of anxiety and depression, we used an independent samples t-test, with anxiety and depression being the dependent variable, and campus involvement and student housing being the independent variables. We also conducted a t-test to measure the effects of student counseling (inside/outside the university) on depression and anxiety.

Procedure

Participants partook in an online survey administered through North Georgia Electronic Database. Participants took the survey at a time of their convenience and were given a consent form, educated on the purpose of the study, risks/benefits of participating, and contact information. They then proceeded to fill out the questions in the survey.

RESULTS

Predictors of Anxiety

A multiple linear regression analysis was conducted in order to measure predictors of anxiety among college students. Results suggest that students' academic stress, own expectations, depression, loneliness, social support, and test anxiety, explain a significant proportion of anxiety levels R = .643, F (7, 316) = 81.473. Depression was a significant predictor of Anxiety, B = .562, t (101) = 7.451, p <.001. Additionally, there was a significant predictor of academic stress on anxiety, B = .281, t (101) = 4.015, p < .001. Students own expectations were a significant predictor of anxiety as well, B = - .206, t (101) = -3.666, p < .001. Results showed that social support was not a significant predictor of anxiety, B = -.013, t (101) = -.211, p = .833. This means that a lack of social support did not predict increased anxiety. Test anxiety was not a significant predictor of anxiety, B = .088, t (101) = 1.324, p = .188. In layman's terms, test anxiety did not lead to increased amounts of anxiety among university students. Parent/teacher academic expectations was not a significant predictor of anxiety B = .014, t (101) = .257, p =.798. This means expectations of parents and teachers did not contribute to students' anxiety. Loneliness was not a significant predictor of anxiety, B = -.020, t (101) = -.282, p = .778. This means that students who reported loneliness did not have significantly more anxiety than students who reported lower scores in the loneliness index. The R^2 value is .697, meaning 69.7% of the variation in anxiety levels can be explained by social support, academic stress, parent-teacher expectations, own expectations, test anxiety, and loneliness.

Anxiety by Class

Within the sample of freshmen students (n = 231), results indicate that academic stress, own expectations, loneliness, social support, test anxiety, and depression explain a significant proportion of students' anxiety levels R^2 = .649, F (6, 224) = 69.07, p < .001. Depression (M = 2.02, SD = 0.79) was found to be a significant predictor of students' anxiety B = .698, t (224) = 10.968, p < .001. Own expectations (M = 2.29, SD = 0.99) was found to be a significant predictor of students' anxiety B = -.107, t (224) = -2.579, p = .011. Academic stress (M = 3.14, SD = 0.83) was also found to be a significant predictor of students' anxiety B = .109, t (224) = 1.975, p = .049.

Within the sample of sophomore students (n = 57), results show that academic stress, own expectations, loneliness, social support, test anxiety, and depression explain a significant proportion of students' anxiety levels R^2 = .676, F (6, 50) = 17.35, p < .001. Depression (M = 1.82, SD = 0.66) was found to be a significant predictor of students' anxiety B = .602, t (50) = 4.233, p < .001. Own expectations (M = 2.35, SD = 1.05) was also found to be a significant predictor of students' anxiety B = -.298, t (50) = -3.682, p = .001.

Within the sample of junior students (n = 28), results show that academic stress, own expectations, loneliness, social support, test anxiety, and depression explain a significant proportion of students' anxiety levels R^2 = .582, F (6, 21) = 4.88, p = .003. Depression (M = 1.92, SD = 0.67) was found to be a significant predictor of students' anxiety B = .787, t (21) = 2.60, p = .017. There were no significant predictors of anxiety found within the sample of senior students (n = 8) R^2 = .997, F (6, 1) = 48.47, p = .110. This result could be explained by the small sample of seniors that participated in our study.

Financial Worry

An independent samples t-test was performed comparing students' financial worry in two different conditions: students who had a job and those who did not. When asking students "Are financial concerns a current issue?", a significant difference was found in students who had a job outside of school (n = 65, M = 2.68, SD = 1.08) compared to those who did not have a job (n = 40, M = 2.10, SD = 1.01); t (103) = 2.731, p = .007. In layman's terms, this means that students who did have a job expressed more financial concern than those who did not have a job.

When students were asked, "To what extent does your debt worry you?", there was no significant difference between those who had a job (n = 62, M = 2.34 SD = 1.16) and those who did not (n = 39, M = 2.18, SD = 1.14), t (99) = .676, p = .501. In layman's terms, students' financial worry did not fluctuate according to their current job status. An additional independent samples t-test was performed comparing students' financial worry in two conditions: students who have attended counseling and those who have not. There was no significant difference found when asking students who have attended counseling outside of UNG (n = 30, M = 2.60, SD = 1.00), "Are financial concerns a current issue?" and asking those who have not attended counseling outside of UNG (n = 75, M = 2.40, SD = 1.12); t (103) = .853, p = .395. Furthermore, no significant differences were found in financial concern for students who attended counseling at the university (n = 11, M = 2.82, SD = 1.17) versus students who did not attend counseling at the university (n = 93, M = 2.43, SD = 1.07); t (102) = 1.130, p = .261.

When asking students "To what extent does your debt worry you?", there was no significant difference found between those who had attended counseling outside of UNG (n = 28, M = 2.46, SD = 1.14) and those who had not attended counseling outside of UNG (n = 73, M = 2.21, SD = 1.15), t (99) = 1.13, p = .314. Furthermore, no significant differences were found between students' who attended counseling at the university (n = 11, M = 2.64, SD = 1.21) and those who did not attend counseling at the university (n = 89, M = 2.25, SD = 1.14), t (98) = 1.061, p = .291. These results indicate that counseling attendance does not affect students' financial concerns.

Effects of Counseling Attendance

An independent samples t-test was performed to measure the effects of counseling attendance outside of UNG on students' perceived social support, academic stress, parent/teacher expectations, own expectations, depression, anxiety, test anxiety, and loneliness. There was a significant difference found in symptoms of depression between students who attended counseling (n = 30, M = 2.34, SD = .83) and those who did not (n = 77, M = 1.90, SD = .74); t (105) = 2.669, p = .009. This means that students who attended counseling outside of UNG experienced significantly more depressive symptoms than those who did not attend counseling. There was also a significant difference found in levels of test anxiety between students who attended counseling outside of UNG (n = 30, M = 3.14, SD = .86) and those who did not (n = 77, M = 2.75, SD = .86); t (105) = 2.128, p = .036. This means that students who attended counseling outside of UNG experienced significantly more test anxiety than those who did not attend counseling. There was no significant difference found in perceived social support between students who attended counseling outside of UNG (n = 30, M = 5.43, SD = 1.23) and those who did not (n = 77, M = 5.55, SD = 1.05); t (105) = -.490, p = .625. There was no significant difference found in academic stress between students who attended counseling outside of UNG (n = 30, M = 3.19, SD = .95) and those who did not (n = 77, M = 3.06, SD = .81); t (105) = .730, p = .467. There was no significant difference found in parents/teachers expectations between students who attended counseling outside of UNG (n = 30, M = 2.93, SD = .57) and those who did not (n = 77, M = 2.90, SD = .52); t (105) = .210, p = .834. There was no significant difference found in students' own expectations between those who attended counseling outside of UNG (n = 30, M = 2.06, SD = .88) and those who did not (n = 76, M = 2.47, SD = 1.10); t (104) = -1.832, p = .070. There was no significant difference found in anxiety between students who attended counseling outside of UNG (n = 30, M = 2.49, SD = .83) and those who did not (n = 76, M = 2.13, SD = .90); t (104) = 1.881, p = .063. There was no significant difference found in loneliness between students who attended counseling outside of UNG (n = 30, M = 2.39, SD = .74) and those who did not (n = 77, M = 2.22, SD = .69); t (105) = 1.116, p = .267.

An independent samples t-test was performed to measure the effects of counseling attendance at the university on students' perceived social support, academic stress, parent/teacher expectations, own expectations, depression, anxiety, test anxiety, and loneliness. There was a significant difference found in social support between students who attended counseling at the university (n = 12, M = 4.93, SD = 1.17) and those who did not (n = 94, M = 5.59, SD = 1.08); t (104) = -1.991, p = .049. This means that students who attended counseling at the university perceived to have less social support than those who did not attend counseling at the university. There was no significant difference found in academic stress between students who attended counseling at the university (n = 12, M = 3.08, SD = .70) and those who did not (n = 94, M = 3.11, SD = .86); t (104) = -.109, p = .914. There was no significant difference found in parents/teachers expectations between students who attended counseling at the university (n = 12, M = 2.81, SD = .59) and those who did not (n = 94, M = 2.94, SD = .51); t (104) = -.786, p = .434. There was no significant difference found in students' own expectations between those who attended counseling at the university (n = 12, M = 2.44, SD = .89) and those who did not (n = 93, M = 2.33, SD = 1.08); t (103) = .320, p = .750. There was no significant difference found in depression between students who attended counseling at the university (n = 12, M = 2.13, SD = .80) and those who did not (n = 94, M = 1.10, SD = .79); t (104) = .565, p = .573.

There was no significant difference found in anxiety between students who attended counseling at the university (n = 12, M = 2.29, SD = .93) and those who did not (n = 93, M = 2.24, SD = .89); t (103) = .200, p = .842. There was no significant difference found in test anxiety between students who attended counseling at the university (n = 12, M = 2.81, SD = 1.05) and those who did not (n = 94, M = 2.86, SD = .86); t (104) = -.216, p = .830. There was no significant difference found in loneliness between students who attended counseling at the university (n = 12, M = 2.60, SD = .55) and those who did not (n = 94, M = 2.24, SD = .71); t (104) = 1.735, p = .086.

Counseling Attendance by Class

For students attending counseling outside of UNG, freshman reported significant levels of anxiety (F = 4.776, p = .30, t (229) = 5.288). Additionally, seniors attending counseling outside of UNG reported significant levels of anxiety (F = 7.043, p = .029, t (8) = 3.235) and depression (F = 9.207, t (6) = .023, p = 1.108). This is interesting because we had a small sample size of seniors (8-10 reported, compared to 213 freshman), yet there were high levels of anxiety and depression among those going to a counselor outside of UNG. No other significant differences were found concerning class level and counseling at UNG and outside of UNG.

Loneliness on Anxiety and Depression

A simple linear regression test was conducted to measure the effects of loneliness on depression. Loneliness had a significant proportion of variance on depression $R^2 = .349$, $F\ (1, 324) = 173.510$, $p < .001$. There was a significant relationship found between students depression' levels and loneliness ($p < .001$). This supports our hypothesis that loneliness is a predictor of depression. Therefore, if students are lonely, they are likely to have higher levels of depression.

Similarly, a simple linear regression was conducted to measure the effects of loneliness on anxiety. A significant proportion of loneliness symptoms was explained by anxiety $B = .064$, $t\ (316) = 1.401$, $p < .001$. A significant relationship was found between students' anxiety levels and loneliness ($p < .001$). This means that loneliness is a predictor of anxiety among college students; Therefore, if students are lonely, they are more likely to have higher levels of anxiety.

Student housing and anxiety and depression

An independent samples t-test was conducted to compare anxiety and depression levels between students living on campus and students who commute to campus. Two separate independent sample t-tests were conducted, one measuring depression as the dependent and one measuring anxiety as the dependent. There was no significant difference found in depression symptoms between students living on campus ($M = 1.84$, $SD = 0.76$) and commuter students ($M = 2.12$, $SD = 0.79$); $t\ (105) = -1.637$, $p = 0.105$. There was no significant difference found in anxiety scores between students living on campus ($M = 2.05$, $SD = 0.74$) and commuter students ($M = 2.32$, $SD = 0.95$); $t\ (104) = -1.506$, $p = 0.135$. The results show that anxiety and depression scores do not differ between on-campus residents and commuter students. These results do not align with our hypothesis, stating that students living on campus would experience lower levels of anxiety and depression. This means that students' living situation does not significantly affect their anxiety and depression levels.

Depression by Class

Within the sample of freshmen students (n = 231), results indicate that academic stress, own expectations, loneliness, social support, test anxiety, and anxiety explain a significant proportion of students' depression levels R^2 = .687, F (6, 224) = 81.768, p < .001. Loneliness (M = 2.32, SD = 0.72) was found to be a significant predictor of students' depression B = .250, t (224) = 4.569, p < .001. Test anxiety (M = 2.96, SD = 0.95) was found to be a significant predictor of students' depression B = .121, t (224) = 3.092, p = .002. Anxiety (M = 2.28, SD = 0.88) was also found to be a significant predictor of students' depression B = .501, t (224) = 10.968, p < .001.

Within the sample of sophomore students (n = 57), results indicate that academic stress, own expectations, loneliness, social support, test anxiety, and anxiety explain a significant proportion of students' depression levels R^2 = .603, F (6, 50) = 12.643, p < .001. Social support (M = 5.25, SD = 1.37) was found to be a significant predictor of students' depression B = -.139, t (50) = -2.748, p = .008. Anxiety (M = 2.16, SD = 0.86) was also found to be a significant predictor of students' depression B = .438, t (50) = 4.233, p < .001.

Within the sample of junior students (n = 28), results indicate that academic stress, own expectations, loneliness, social support, test anxiety, and anxiety explain a significant proportion of junior's depression levels R^2 = .740, F (6, 21) = 9.943, p < .001. Social support (M = 5.72, SD = 0.89) was found to be a significant predictor of students' depression B = -.345, t (21) = -2.762, p = .012. Test anxiety (M = 2.81, SD = 0.84) was found to be a significant predictor of students' depression B = .289, t (21) = 2.219, p = .038. Anxiety (M = 2.09, SD = 0.85) was also found to be a significant predictor of students' depression B = .310, t (21) = 2.60, p = .47.

There were no significant predictors of depression found within the sample of senior students (n = 8) R^2 = .968, F (6, 1) = 5.098, p =.327. Like with anxiety, this result could be explained by the small sample of seniors that participated in our study.

DISCUSSION

According to Andrews and Wilding's (2004) study, students who exhibit no signs of significant psychological distress before starting college are often diagnosed with depression and generalized anxiety disorder halfway through their college career. These findings correlate to our results, indicating that academic stress is a significant predictor of anxiety amongst college students. The greater the academic stress that students experience, that more anxiety they will experience. Similarly, our results indicated that students' own expectations significantly correlated to their level of anxiety. Students are exposed to these factors while in college, which explains why anxiety levels tend to rise after students begin college. Furthermore, our results also correlate to Jones et al.'s (2017) research, in which they found that academic stress accounted for the greatest variance of anxiety in comparison to financial stress and family and peer support. In correlation to our study, we found that social support was not a significant predictor of anxiety in college students. These results support our hypothesis that there is a positive correlation between academic stress and anxiety among college students.

According to McIntyre et al. (2017), the lack of available resources, such as time, money, and sleep, significantly affects students' level of stress they experience while in college. These results are similar to our results found when measuring students' financial stress in correlation to their employment status. Students who were employed indicated greater financial stress than those who were unemployed. These results may be due to students' lack of income, which is why they needed employment in the first place. They may have different circumstances in which they are fully responsible for their financial burdens, without any help from parents or family. Some results found in previous literature indicate that students who struggle financially often need additional support, such as counseling or therapy, but do not acknowledge the need for this support (Nash et al., 2017). In our results, we found that students financial concern was not correlated to counseling attendance. In other words, there was no significant difference in financial worry between those who attended counseling and those who did not. These results may be due to the lack of acknowledgement of financial stress during therapy sessions. Students may not think that their financial stress is important enough to talk about while in therapy. On the other hand, students who struggle with financial stress may not actually need therapy to cope with their stress. This may be something that most students work through on their own, which would explain the lack of significance in financial stress between those who see a counselor and those who do not. These results do not support our hypothesis that perceived financial support has a significant effect on the psychological well-being of college students.

Although we did not find a direct correlation between students' involvement on campus and their financial support, we can assume from the results indicated in the previous paragraph that financial worry leads to diminished involvement in activities on campus. This interpretation is applicable because if students are spending time working, as well as going to school, they have less time to be involved on campus.

In Watson, Barber, and Dziurawiec's (2016) research, they found that students' place of residency plays a significant role in their psychological well-being. Students who lived away from their parents/guardians and received minimal financial support from family exhibited significant psychological and financial stress compared to those still living at home. These results were uncorrelated to the results of our study, indicating that anxiety and depression symptoms did not differ between those who lived on campus and those who commuted. One limitation to interpreting this result is that we do not know if commuters were commuting from their home or from an apartment off campus. Furthermore, in looking at loneliness between students who commuted and those who lived on campus, our results show that loneliness significantly predicts depression and anxiety in college students. But there is no significant difference between depression and anxiety in commuters versus those who live on campus. Therefore, we can determine that loneliness is not significantly different between commuters and those who live on campus. However, greater exploration of how student residency affects loneliness should be done in order to adequately interpret this result.

It is evident that across the entire student population, many students are suffering from comorbid depression and anxiety disorder symptoms. While our multiple regression analyses show that there were no significant predictors found affecting seniors' anxiety and depression levels, our t-test analysis of counseling attendance shows that seniors attending counseling outside of UNG exhibited significantly high levels of depression and anxiety. These results could be due to the fact that many students hold off on going to counseling until their symptoms are so exacerbated that they cannot cope. The reason that students frequently wait until their symptoms are severe may be due to the fact that they are not fully aware of how serious their symptoms are. They may write them off as just being "tired" from stretching themselves too thin and not realize that what they are actually experiencing is depression. Despite the small proportion of seniors who participated in our study, they exhibited the highest levels of depression and anxiety out of all the students who completed the study. This means that seniors who are not attending counseling are most likely in need of help and will continue to wait until their symptoms progress. Seniors have a significant amount of pressure that they have to endure compared to other classes, which may be another reason why they exhibit greater symptoms. They are immersed in the stress of graduating, finding a job/going to graduate school, coping with changing circumstances, etc. Other conclusions found from our results indicate that freshmen, sophomores, and juniors often exhibit relatively similar levels of depression and anxiety. Similarly, the ratio of those who

attend counseling vs. those who do not attend counseling at UNG is consistent across all groups, excluding seniors. Only a small proportion of students attended counseling at UNG. The ratio of students who attended counseling outside of UNG was also relatively consistent across all groups of students, this time including seniors; However, there were significantly more students who engaged in counseling outside of UNG compared to at the university. These results may be due to students transferring in from other campuses. Another explanation could be that students already have an established relationship with their counselor outside of UNG, so they do not feel the need to see a counselor at UNG.

Limitations of the present study include the inability to obtain a large sample size. This contributes to the lack of external validity our study holds and inhibits us from generalizing our findings to the larger population. However, our study exemplifies strong measurement validity, as each scale used was obtained from previous scholarly research. Another limitation of our study includes the significant number of predictors being measured. Measuring the significance of every predictor of depression and anxiety, as well as the relationship between each predictor, becomes confusing and ambiguous when interpreting the results.

Overall, results from our study indicate that depression and anxiety is a significant concern amongst college students, and many students who experience increased levels of depression and anxiety are seeking help through counseling services. Specifically, students who struggled with depression, test anxiety, and lack of social support were the students that sought out counseling the most. While many students are seeking out help, there are still a number of students in need of counseling services. This reason, in particular, is why it is important to keep advocating for mental health and spreading awareness to students about the psychological benefits of attending counseling. Further research should be done investigating the specific effects that come from attending counseling and how students' levels of depression and anxiety are managed by these services. Additionally, it would be beneficial to perform longitudinal research on symptoms of depression and anxiety, the stressors associated with depression and anxiety, and how students are affected by these disorders throughout their college career.

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Examining Techniques to Mitigate Misinformation on Social Media: Related Articles vs Social Engagement

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ABSTRACT

There is a great deal of interest in research that focuses on finding ways to control the spread of misinformation on social media networks. Prior research examined a SMN feature called "related articles" to provide context directly under SMN posts with potentially misinformed content about controversial topics. Other research examined how SMN users were encouraged to consume online news sources outside their comfort zone when participating within a socialized environment. Each of these features separately were found to significantly reduced misperceptions of SMN users. In this study, we examine how both features can work together to reduce the spread of misinformation. We use an experimental survey to measure the effectiveness of SMN features in correcting misperceptions of SMN users and provide results to inform government, cybersecurity firms, social media companies, and SMN users.

Keywords: Social media, misinformation, mitigating, related articles, social engagements, cybersecurity

Mounting evidence indicates that social media networks (SMNs) have the potential to be weaponized for individual and societal harm. For example, the United States Intelligence Community (USIC), which is comprised of multiple federal agencies including the CIA, FBI, and NSA, released a joint statement with the Department of Homeland Security that implicated the Russian government in using SMN outlets like Twitter and Facebook to influence the 2016 Presidential election with "information Warfare" (Clark, 2018). Another incident is where the United Nations issued a citation to Facebook because the SMN was used to incite violence against the Rohingya minority group in Myanmar (Miles, 2018). These incidences surrounding the weaponization of social media echo patterns in history that show that the rapid expansion of public's ability to express itself can cause the fall of empires, wars, and even genocides (Goolsby, 2013; Hempel, 2016; Roose & Mozur, 2018).

INTRODUCTION

The urgency of this study stems from the potential danger of US citizens becoming disenchanted from democratic norms such as voting or deciding whether to support a candidate for public office based off false information sources (Fuchs, Kenney, Perina, & VanDoorn, 2017). Advanced democracies like the United States are not immune from the kind of violence that SMN sparked in Myanmar either. In 2017, a similar incident happened in Charleston, Virginia in which SMN was used by hate groups to arrange rallies where dozens of people ended up being injured and one woman was killed (Francie, 2017). To effectively mitigate conflicts that may arise from the wide adoption of SMN, major SMN platforms like Twitter and Facebook should implement tools that reduce the spread of misinformation. Hostile governments have disseminated misinformation on SMN to meddle in the affairs of other governments across the world, resulting widespread societal division. The fabric of democracy itself may depend, if not to a large extent, on SMN companies accomplishing this task (Bennett & Livingston, 2018).

One solution that has promise is to simultaneously "swamp" SMN users with factual sources of information while being exposed to misinformation (Alemanno, 2018; Bode & Vraga, 2015). Studies have shown that providing more contextual information surrounding a controversial topic can mitigate misinformation and have a positive influence on the perceptions of respondents. We have also found studies that suggest that the presence of social interactions in the form of endorsements on SMNs can influence the preferences of SMN users when it comes to selecting news sources (Messing & Westwood, 2014). However, these prior studies do not examine the influence of input from other SMN users to correct misperceptions on the same platform when competing against the influence of the related articles feature. This study addresses this gap by examining SMN user behavior regarding misinformation in the presence of interacting with other SMN users, and the related articles feature which shows information related to a controversial topic.

Our research question of interest is, "How is SMN user perception of controversial information impacted by SMN features and the social context of SMN?" To address this question, we integrate Social Information Processing (SIP) Theory and Social Cognitive Theory (SCT) to test and understand the process of changing the perceptions and behaviors of SMN. Using an experimental survey, we will test the efficacy of related articles.

The remainder of this paper is organized as follows. First, we discuss existing research related to mitigating misinformation on social media. Second, we integrate Social Information Processing Theory and Social Cognitive Theory to guide our examination of mitigation techniques and develop hypotheses. Third, we discuss the experimental survey methodology, including data collection and data analysis. Lastly, we conclude with the implications of our study for academia and practice.

THEORETICAL BACKGROUND

Alemanno (2018) detailed various approaches that could be implemented by government and social media companies to mitigate misinformation. He deduced that the most expedient measure would be for social media companies to provide context for factually dubious content on their platforms by offering related articles directly beneath the disputed content. Bode and Vraga (2015) examined this technique by attaching "related articles" to news articles outside the SMN platform whenever a controversial topic was posted. The study found that misperceptions were changed by exposure to corrective information within social media, i.e., corrective articles (related stories). However, their study strictly focused on the efficacy of using the "related articles" feature alone to correct misinformation. In our research, we will test the efficacy of the related articles feature to correct misinformation within the context of SMN connections providing input on the controversial topic.

In 2015, Messing and Westwood (2015) published a study titled *Selective Exposure in the Age of Social Media: Endorsements Trump Partisan Source Affiliation When Selecting News Online* that examined whether endorsements on social media websites increased the probability of SMN users selecting content. They found that SMN users were encouraged to consume more heterogenous Internet news sources when operating within a socialized environment. More specifically, the socialization of Internet news occurred when social media endorsements of content by 3rd party organizations, or by average SMN users were present. In our study, we adapt the concepts of social media endorsements and partner it with the related articles approach to develop a more comprehensive approach to mitigating the spread of misinformation. Additionally, our study is guided by the concepts from two theories: Social Cognitive Theory, and Social Information Processing Theory.

Social Information Processing

Social Information Processing (SIP) theory has been used extensively within information systems (IS) research to examine the role of computer-mediated communication (CMC) (i.e., interpersonal communication via electronic mediums) in shaping human behavior (Walther, 1992, 1996). For example, Gallivan et al. (2005) examined how employees adopt new information technology (IT) in both an individual and social context. The researchers found that individual factors surrounding an employee's adoption of IT were dwarfed by the social factors of SIP, specifically that "an employee's IT usage will be related to the level of his coworker's average IT use" (Gallivan et al., 2005). In this study, we use SIP to investigate how SMN users select content within the social context of a social media network.

There are three core elements in SIP: the sender, the receiver, and feedback. The sender refers to the person who presents themselves in an optimized manner to others via CMC (Walther, 1996) In our study, the sender is viewed as the news organization or an average user that posts a news story via CMC in the form of a social media network. In SIP, the receiver refers to the CMC message receiver who exaggerates their impression of the sender (Walther, 1996). In our study, the receiver is the SMN user that is exposed to a news story on a SMN. Lastly, in SIP, feedback refers to how the sense of intimacy that builds over time between the sender and receiver is amplified through a process called behavioral confirmation (Walther, 1996). In our study, feedback is used as the response of an SMN user (i.e., the receiver) to news stores posted on a SMN by 3rd party organizations or other SMN users (i.e., the sender).

Social Cognitive Theory

Social Cognitive Theory (SCT) has been used to examine how people learn new behaviors through the threefold influence of personal factors (i.e., cognitive, emotional, and biological), behavioral patterns, and environmental factors (Bandura, 2001). One of its main concepts is that people can learn new behaviors by observation in addition to direct experience (Bandura, 2001). The simplicity of this theory was demonstrated in a famous study known as "The Bobo Doll Experiment." (Bandura et al., 1963)1 group of experimental Ss observed real-life aggressive models, a 2nd observed these same models portraying aggression on film, while a 3rd group viewed a film depicting an aggressive cartoon character. Following the exposure treatment, Ss were mildly frustrated and tested for the amount of imitative and nonimitative aggression in a different experimental setting. The overall results provide evidence for both the facilitating and the modeling influence of film-mediated aggressive stimulation. In addition, the findings reveal that the effects of such exposure are to some extent a function of the sex of the model, sex of the child, and the reality cues of the mod","container-title":"Journal of Abnormal & Social Psychology","ISSN":"0096851X","issue":"1","journalAbbreviation":"Journal of Abnormal & Social Psychology","page":"3","source":"EBSCOhost","title":"Imitation of Film-Mediated Aggressive Models","volume":"66","author":[{"family":"Bandura","given":"Albert"},{"family":"Ross","given":"Dorothea"},{"family":"Ross","given":"Sheila A."}],"issued":{"date-parts":[["1963",1]]}}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} . Two separate groups of children were tasked with observing the behaviors of adults with a Bobo Doll. Based on their observations, the children learned to either physically attack or leave the Bobo Doll alone (Bandura, Ross, & Ross, 1963). This study highlights the importance of social endorsements when individuals are learning new behaviors. Specifically, in the experiment, the adult made a social endorsement of hitting the Bobo Doll, and because of that social endorsement, the children replicated that same behavior. On social media networks, SMN users can be encouraged to select certain news content based on the presence of social endorsements by 3rd party organizations or by the SMN user's connections.

Another application of SCT involves examining how people with spinal cord injuries can enhance their amount of physical activity (Wilroy & Turner, 2016). Wilroy and Turner found that people with a strong foundation of social support were more likely to partake in physical exercise (Wilroy & Turner, 2016). This is due to the fact that observational learning, participants viewing others exercising and benefitting from it, had the effect of making the participants were more likely to partake in the habit of exercise themselves (Martin Ginis et al., 2011)direct predictor. Self-regulatory efficacy and outcome expectations had indirect effects, mediated by self-regulation.\nSocial Cognitive Theory is useful for predicting physical activity in people with spinal cord injury. Self-regulation is the most potent Social Cognitive Theory predictor of physical activity in people with spinal cord injury. Self-regulation and its determinants should be targeted in physical activity-enhancing interventions.[PUBLICATION ABSTRACT]",”container-title”:”Annals of Behavioral Medicine; New York”,”DOI”:”http://dx.doi.org/10.1007/s12160-011-9278-9”,”ISSN”:”08836612”,”issue”:”1”,”language”:”English”,”page”:”127-33”,”source”:”ProQuest”,”title”:”Determinants of Physical Activity Among People with Spinal Cord Injury: A Test of Social Cognitive Theory”,”title-short”:”Determinants of Physical Activity Among People with Spinal Cord Injury”,”volume”:”42”,”author”:[{“family”:”Martin Ginis”,”given”:”Kathleen A.”},{“family”:”Latimer”,”given”:”Amy E.”},{“family”:”Arbour-nicitopoulos”,”given”:”Kelly P.”},{“family”:”Bassett”,”given”:”Rebecca L.”},{“family”:”Wolfe”,”given”:”Dalton L.”},{“family”:”Hanna”,”given”:”Steven E.”}],”issued”:{“date-parts”:[[“2011”,8]]}}}],”schema”:”https://github.com/citation-style-language/schema/raw/master/csl-citation.json”}. In our study, we will examine how the role of social influence on SMNs can affect the perceptions of SMN users who are exposed to misinformed content. Specifically, it is the observational role of learning within SCT that will be the focus in our study.

RESEARCH MODEL

We developed a research model that examines the correlation between interactions on social media networks (SMN), and the presence of related articles under shared SMN content to mitigate the spread of misinformation. Our model includes three sets of variables that are all related to the dependent variable, which is feedback from SMN users exposed to the SMN posts. These include (1) the sender (news organization that shares content in the form of news stories); (2) social endorsements (“likes” from average users and organizations); and (3) the presence of related articles under social media posts to provide context to the news stories shared. We will now summarize the logic for each hypothesis in the model.

Our first hypothesis is based on the control group in this study, which will not receive any treatments (i.e., variable changes). Since treatments are generally considered more successful if subjects respond more favorably to variable changes than the control group, we assume:

> *H0 (control): SMN user attitudes on controversial topics do not change when shown misinformed content with no related articles or endorsements.*

The rest of our hypotheses address two groups of participants: those who hold no initial misconceptions about the controversial topics used in our survey, and those who have initial misperceptions about the same controversial topics used in our survey. The hypotheses for both groups of participants are based around three research questions:

(RQ1a) Among those with no initial mis-perceptions and those who have initial misperceptions (RQ1b) on a controversial topic, to what extent will SMN user attitudes on a controversial topic change in the presence of Social Endorsements?

(RQ2a) Among those with no initial mis-perceptions and those who have initial misperceptions (RQ2b) on a controversial topic,, to what extent will SMN user attitudes on a controversial topic change in the presence of the related articles feature?

(RQ3a) Among those with no initial mis-perceptions and those who have initial misperceptions (RQ3b) on a controversial topic, to what extent will SMN user attitudes on a controversial topic change in the presence of the related articles feature and Social Endorsements?

For RQ1a, the presence of social endorsements may change SMN user attitudes depending on whether there is a high or low amount of social endorsements. Our literature review mentions how the presence of social endorsements can encourage SMN users to read content outside their usual choice of sources, thus opening them up to new ideas. We assume:

> *H1a: In the presence of HIGH-level Social Endorsements, there will be a shift in the attitudes of SMN users with no initial misperceptions towards confirming the misinformed SMN content.*

Our literature review does not support SMN user attitudes on a controversial topic changing with low levels of social endorsements. Thus, we assume:

> *H1b: In the presence of LOW-level Social Endorsements, there will be no change in the attitudes of SMN users.*

For RQ2a, we examined how the presence of related articles can change the attitudes of SMN users with no initial misperceptions on the controversial topics used in our survey. Our literature review found that related articles that dis-confirmed misinformed SMN content could correct misperceptions of SMN users who viewed the content, but the correcting effect of the dis-confirming related articles was non-existent for people who did not already hold misperceptions about the controversial topic. Consequently, we assume:

H2a: In the presence of the related articles feature that CONFIRM the misinformed content, there will be no change in the attitudes of SMN users with no initial misperceptions.

H2b: In the presence of the related articles feature that DIS-CONFIRM the misinformed content, there will be no change in the attitudes of SMN users with no initial misperceptions towards dis-confirming the misinformation shown.

For RQ3a, we combined the related articles feature and social endorsements to see what effect it would have on changing the attitudes of SMN users with no initial misperceptions who are exposed to SMN content. Following the results in our literature review which show that the related articles feature does not change the attitudes of SMN Users who have no initial misperceptions towards misinformed controversial content, and that social endorsements encourage SMN users to view information outside their usual content sources, we make the following assumptions:

H3a: In the presence of the related articles feature that CONFIRM the misinformed content and HIGH-level Social Endorsements, the attitudes of SMN users with no initial misperceptions will shift towards confirming the misinformation.

H3b: In the presence of the related articles feature that CONFIRM the misinformed content and LOW-level Social Endorsements, the attitudes of SMN users with no initial misperceptions will not change.

The next set of hypotheses are based on SMN users who do have misperceptions about the controversial topics used in our experimental survey. RQ1b examines the extent to which this group of participants in our study will change their attitudes on a controversial topic in the presence of social endorsements. Following the same studies in our literature review that show the capability of social endorsements to influence the content choices of SMN users, we make the following assumptions:

H4a: In the presence of HIGH-level Social Endorsements, SMN user attitudes on a controversial topic will shift towards confirming the misinformation.

H4b: In the presence of LOW-level Social Endorsements, SMN user attitudes on a controversial topic will not change.

RQ2b examines the extent to which SMN users with initial misperceptions on a controversial topic will shift their attitudes in the presence of the related articles feature. The studies in our literature review suggest that the related articles feature can correct the misperceptions of SMN users. Thus we make the following assumptions:

H5a: In the presence of the related articles feature that CONFIRMS the misinformed content, there will be no change in the attitudes of SMN users with no initial misperceptions.

H5b: In the presence of the related articles feature that DIS-CONFIRMS the misinformed content, there will be a change in the attitudes of SMN users with initial misperceptions towards dis-confirming the misinformation.

R3b examines the extent to which SMN users with initial misperceptions on a controversial topic will shift their attitudes in the presence of combining the related articles feature and social endorsements. The prior research from our literature review suggests that the related articles feature is effective in correcting the initial misperceptions of SMN users, and that social endorsements are influential in how SMN users choose their source of content. Thus, we make the following assumptions:

H6a: In the presence of the related articles feature that CONFIRMS the misinformed content and HIGH-level Social Endorsements, there will be a change in SMN user attitudes towards confirming the misinformation.

H6b: In the presence of the related articles feature that CONFIRMS the misinformed content and LOW-level Social Endorsements, there will be no change in SMN user attitudes towards confirming the misinformation.

H6c: In the presence of the related articles feature that DIS-CONFIRMS the misinformed content and HIGH-level Social Endorsements, there will be a change in SMN user attitudes towards dis-confirming the misinformation.

H6d: In the presence of the related articles feature that DIS-CONFIRMS the misinformed content and LOW-level Social Endorsements, there will be a change in SMN user attitudes towards dis-confirming the misinformation.

RESEARCH METHODS

Our study will use an experimental survey to measure the efficacy of the related articles feature and social endorsements in correcting misperceptions about controversial topics on social media. There will be eight treatments and one control group. Whereas the treatment groups will receive varying combinations of related articles confirming or dis-confirming misinformed SMN content on controversial topics in addition to social endorsements, the control group will receive no treatments. The treatments and control group will be tested using a simulated social media post.

Figure 1: Simulated Social Media Post - Climate Change
Black outlines are not shown in actual survey

There are two controversial topics covered in our study: climate change, and vaccines.

The related articles that dis-confirm the misinformed SMN content on controversial topics will be derived from a popular bias-measuring news source chart (Langlois, 2016). We also used a random number generator to simulate social endorsements in the form of likes and comments for each article. High-level endorsements are represented by a number above 10,000, and low-level likes are represented by a number below 1000 (Bode & Vraga, 2015).

The experimental survey has three phases: pre-test, experimental survey, and post-test. A pre-test will be given to measure the respondent's attitudes on the controversial topics chosen for the study. The experimental survey will contain treatments for the two groups of participants (i.e., those with initial misperceptions, and those without initial misperceptions) with various combinations of the related articles feature and social endorsements. A post-test will be given in the final stage of the study after the experimental survey to measure any changes in the respondent's attitudes about the controversial topics. Using the Qualtrics survey tool and its randomization features, all respondents will be assigned to one of eight treatment groups or the control group.

Figure 1 highlights the design layout examples for the control and treatment groups using the climate change topic as an example. The dashed black line highlights the related articles section of the social media posts where news articles that provide varying perspective on the controversial topic are provided. The solid black lines highlight the social endorsement sections of the social media posts in the form of "likes" and comments by other SMN users.

DATA ANALYSIS

We collected 112 complete responses from 145 respondents by using a survey made through Qualtrics. Most of the responses were collected from college students from the University of North Georgia over several months. The remaining responses were collected via public Reddit survey pages and the Facebook community. After collecting the data, incomplete responses were removed from the data analysis. Table 1 shows the demographic results.

Sample Characteristics	*n* = 112		
Characteristic		**Frequency**	**Percent**
Age:	18–19	11	10%
	20-24	69	62%
	25-29	14	13%
	30-34	7	6%
	35-39	5	4%
	40-49	5	4%
	60+	1	1%
Race	White	64	57%
	Black or African American	7	6%
	American Indian or Alaska Native	0	0%
	Asian	8	7%
	Native Hawaiian or Pacific Islander	1	1%
	Hispanic	22	20%
	Other	10	9%
Education	High school diploma or less	1	14%
	GED or alternative credential	0	0%
	Some college	33	29%
	Associates degree	43	38%
	Bachelor's degree	12	11%
	Master's degree	7	6%
	Professional degree (e.g., MD, JD)	0	0%
	Doctoral Degree (e.g., Ph.D., EdD)	2	2%
Income	Less than 20K	35	31%
	20-29K	13	12%
	30-39K	15	13%
	40-59K	16	14%
		Frequency	**Percent**
Income	60-69K	7	6&
	70-89K	11	10%
	More than 90K+	15	13%

Table 1. Demographics

The majority of the 112 respondents who completed the demographics section of our survey were college students in their twenties and made less than $30K per year, which may affect the generalizability of our study. We will discuss the implications of the demographics further in our discussion section. The data analysis for our research was done with a pair-wise t-test analysis using statistical software. Figure 2 shows that all pre-test and post-test questions except one question about vaccines are statistically significant. We will explore these results in-depth in the following paragraphs.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	CC_CCA_1_Post Test - CC_CCA_1	-2.145	1.660	.224	-2.594	-1.697	-9.584	54	.000
Pair 2	CC_CCA_2_Post Test - CC_CCA_2	-1.982	1.841	.248	-2.479	-1.484	-7.984	54	.000
Pair 3	CC_CCA_3_Post Test - CC_CCA_3	-1.800	1.638	.221	-2.243	-1.357	-8.152	54	.000
Pair 4	VA_VA_1_Post Test - VA_VA_1	-2.276	1.472	.193	-2.663	-1.889	-11.771	57	.000
Pair 5	VA_VA_2_Post Test - VA_VA_2	.431	1.299	.171	.089	.773	2.527	57	.014
Pair 6	VA_VA_3_Post Test - VA_VA_3	-1.707	1.533	.201	-2.110	-1.304	-8.478	57	.000

Figure 2. Paired Sample Test

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	CC_CCA_1_Post Test - CC_CCA_1	-2.145	1.660	.224	-2.594	-1.697	-9.584	54	.000
Pair 2	CC_CCA_2_Post Test - CC_CCA_2	-1.982	1.841	.248	-2.479	-1.484	-7.984	54	.000
Pair 3	CC_CCA_3_Post Test - CC_CCA_3	-1.800	1.638	.221	-2.243	-1.357	-8.152	54	.000

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	CC_CCA_1_Post Test	2.16	55	1.183	.159
	CC_CCA_1	4.31	55	1.169	.158
Pair 2	CC_CCA_2_Post Test	2.20	55	1.268	.171
	CC_CCA_2	4.18	55	1.321	.178
Pair 3	CC_CCA_3_Post Test	2.18	55	1.278	.172
	CC_CCA_3	3.98	55	1.178	.159

Figure 3. Climate Change Pre-Test & Post Test Results

In Figure 3, Pair 1, the misinformed social media posts about climate change negatively impacted (i.e., lessened) the respondent's belief that climate change is happening by 2.145 points (-1.697, -2.594). This result indicates that the presentation of the misinformed social media post reduced (i.e., decreased away from "strongly agree") respondent's responses by a full 2 points on average from 4.31 to 2.16.

In Figure 3, Pair 2, the misinformed social media posts about climate change negatively impacted (i.e., lessened) the respondent's belief that climate change is a hoax by 1.982 points (-1.484, -2.479). This result indicates that the presentation of the misinformed social media posts reduced respondent's responses (i.e., decreased away from "strongly agree") by a full 2 points on average from 4.18 to 2.20.

In Figure 3, Pair 3, the misinformed social media posts about climate change negatively impacted (i.e., lessened) the respondent's belief that climate change will harm my community by 1.8 points (-1.357, -2.243). This result indicates that the presentation of the misinformed social media posts reduced (i.e., decreased away from "strongly agree") respondent's responses by a full 2 points on average from 3.98 to 2.18.

Since the results are significant, we can now review the results for each of the different types of misinformed social media posts to better understand the negative effects that resulted from the respondents viewing the misinformed social media posts.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
CC_RSM_1	58	1	5	2.74	.160	1.222	1.493
CC_RSM_2	58	1	5	2.66	.153	1.163	1.353
CC_RSM_3	58	1	5	3.09	.158	1.204	1.449
CC_RSM_4	58	1	4	2.17	.130	.994	.987
CC_RSM_5	58	1	5	2.17	.137	1.045	1.093
CC_RSM_6	58	1	5	2.22	.148	1.125	1.265
Valid N (listwise)	58						

Figure 4. Climate Change, Rate Misinformed Social Media Post

Figure 4 shows that by displaying the misinformed social media post without related news articles or social engagements (i.e., likes, comments), respondents rated the *social media post as being interesting* (3.09). However, there were lower-rated responses for finding *the social media post provided new information* (2.74), *was useful* (2.66), *trustworthy* (2.17), *credible* (2.17), or *accurate* (2.22).

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
CC_RISE_1	15	1	3	1.60	.214	.828	.686
CC_RISE_2	15	1	3	1.47	.192	.743	.552
CC_RISE_3	15	1	3	1.67	.211	.816	.667
Valid N (listwise)	15						

Figure 5. Climate Change, Rate Influence of Social Engagements

Figure 5 shows the results from after we altered the misinformed social media post to exaggerate the social engagement values (i.e., likes, comments). This resulted in lower-rated responses for the impact of likes on both topics of the misinformed social media posts in general (i.e., climate-change, vaccines) (1.60), and the impact of social media likes on the climate change post only (1.47). The lower-rated responses on views about climate-change persisted even after increasing the number of likes (1.67).

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
CC_RRA_1	9	1	4	3.00	.441	1.323	1.750
CC_RRA_2	9	1	4	3.00	.441	1.323	1.750
CC_RRA_3	9	1	5	3.22	.465	1.394	1.944
CC_RRA_4	9	1	5	2.78	.465	1.394	1.944
CC_RRA_5	9	1	5	3.11	.423	1.269	1.611
CC_RRA_6	9	1	4	3.00	.373	1.118	1.250
Valid N (listwise)	9						

Figure 6. Climate Change, Rate Related Articles

Figure 6 shows the results what occurred after we altered the misinformed social media post to include the "related articles" feature via providing news article previews and links related to climate change directly under the post, which resulted in higher-rated responses for the articles providing new information (3.00), being useful (3.00), being interesting (3.22), being trustworthy (2.78), being credible (3.11), and being accurate (3.00). These results are noticeably different from the misinformed social media post that had neither related articles nor social engagements, and the misinformed social media post that had social engagements only.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
CC_RISERA_1	25	1	5	2.68	.250	1.249	1.560
CC_RISERA_2	25	1	5	2.76	.247	1.234	1.523
CC_RISERA_3	25	1	5	3.16	.243	1.214	1.473
CC_RISERA_4	25	1	4	2.36	.237	1.186	1.407
CC_RISERA_5	24	1	4	2.29	.229	1.122	1.259
CC_RISERA_6	24	1	5	2.33	.253	1.239	1.536
CC_RISERA_7	24	1	4	2.88	.243	1.191	1.418
CC_RISERA_8	24	1	6	2.96	.285	1.398	1.955
CC_RISERA_9	24	1	5	2.96	.244	1.197	1.433
CC_RISERA_10	24	1	4	2.42	.255	1.248	1.558
CC_RISERA_11	24	1	5	2.50	.262	1.285	1.652
CC_RISERA_12	24	1	4	2.33	.238	1.167	1.362
CC_RISERA_13	24	1	4	1.75	.219	1.073	1.152
CC_RISERA_14	24	1	3	1.50	.181	.885	.783
CC_RISERA_15	24	1	4	1.33	.167	.816	.667
Valid N (listwise)	24						

Figure 7. Climate Change, Rate Influence of Social Engagements and Related Articles

Next, in Figure 7, we combined the treatments (social engagement, and related articles) to examine if multiple treatments, as opposed to one treatment, are effective in countering misinformation. When assessing the social media post itself, respondents found it to be interesting (3.16), which is a higher rating than those who said the post than provided new information (2.68), was useful (2.76), trustworthy (2.36), credible (2.29), or accurate (2.33). The related articles were found to be useful (2.96) and interesting (2.96), which was a higher rating than those who said the misinformed social media post provided new information (2.88), was trustworthy (2.42), credible (2.50), or accurate (2.33). Furthermore, as in the previous results, the rating of social engagements (i.e., likes, comments) were low (1.75), as well as the presence of likes for the climate-change post (1.50), or for an increase in likes being more impactful (1.33).

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 4	VA_VA_1_Post Test - VA_VA_1	-2.276	1.472	.193	-2.663	-1.889	-11.771	57	.000
Pair 5	VA_VA_2_Post Test - VA_VA_2	.431	1.299	.171	.089	.773	2.527	57	.014
Pair 6	VA_VA_3_Post Test - VA_VA_3	-1.707	1.533	.201	-2.110	-1.304	-8.478	57	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	VA_VA_1_Post Test	2.29	58	1.298	.170
	VA_VA_1	4.57	58	.920	.121
Pair 2	VA_VA_2_Post Test	1.90	58	1.135	.149
	VA_VA_2	1.47	58	.959	.126
Pair 3	VA_VA_3_Post Test	2.53	58	1.429	.188
	VA_VA_3	4.24	58	.997	.131

Figure 8. Vaccine Pre-test & Post-test Results

In Figure 8, pre-test and post-test data for questions about vaccines is displayed. The misinformed social media posts about vaccines negatively impacted (i.e., lessened) the respondent's belief that vaccines are important by 2.276 points (-1.889, -2.663). This result indicates that the presentation of the misinformed social media posts reduced respondent's responses by a full 2 points from on average 4.57 to 2.29. The second set of responses will not be assessed since they did not result in significant differences (p=0.14).

Social media posts about vaccines negatively impacted (i.e., lessened) the respondent's belief that vaccinations harm my community by 1.707 points (-1.304, -2.110). This result indicates that the presentation of the misinformed social media posts reduced respondent's responses by a little less than 1.7 points from on average 4.24 to 2.53.

Since the results are significant, we can now review the results for each of the different types of social media posts to better understand these negative effects.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
VA_RSM_1	64	1	5	2.38	.161	1.291	1.667
VA_RSM_2	64	1	5	2.45	.168	1.344	1.807
VA_RSM_3	64	1	5	2.78	.175	1.397	1.951
VA_RSM_4	64	1	5	2.20	.153	1.224	1.498
VA_RSM_5	64	1	5	2.30	.165	1.318	1.736
VA_RSM_6	64	1	5	2.34	.155	1.237	1.531
VA_RSM_7	64	1	5	2.84	.171	1.371	1.880
Valid N (listwise)	64						

Figure 9. Vaccines, Rate Misinformed Social Media Post

Figure 9 shows that by just displaying the misinformed social media post on vaccines without related articles or social engagements (i.e., likes, comments), respondents found the social media post relevant (2.84). However, there were lower-rated responses for finding the social media post provided new information (2.38), was useful (2.45), interesting (2.78), trustworthy (2.20), credible (2.30), or accurate (2.34).

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
VA_RISE_1	29	1	5	1.79	.235	1.264	1.599
VA_RISE_2	29	1	5	1.66	.212	1.143	1.305
VA_RISE_3	29	1	5	1.52	.202	1.090	1.187
Valid N (listwise)	29						

Figure 10. Vaccines, Rate Influence of Social Engagement

Figure 10 shows the results of altering the misinformed social media post to exaggerate the amount social engagement values (i.e., likes, comments), which resulted in lower-rated responses for the impact of likes on belief about vaccines (1.79) on social media in general, the impact of social media likes on the actual misinformed social media post about vaccines used in the survey (1.66), or whether an increase in the number of likes on the misinformed social media post would impact the respondent's view on vaccines (1.52).

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
VA_RRA_1	7	1	5	2.71	.644	1.704	2.905
VA_RRA_2	7	1	4	2.57	.571	1.512	2.286
VA_RRA_3	7	1	4	3.14	.404	1.069	1.143
VA_RRA_4	7	1	4	2.57	.571	1.512	2.286
VA_RRA_5	7	1	4	2.29	.522	1.380	1.905
VA_RRA_6	7	1	5	2.86	.595	1.574	2.476
Valid N (listwise)	7						

Figure 11. Vaccines, Rate Related Articles

Next, in Figure 11, we altered the misinformed social media post to include the related articles feature (i.e., news previews and links related to vaccines from news sources), which resulted in a higher-rated response for the related articles being interesting (3.14). The other results are noteworthy: Articles were rated as providing new information (2.71), being useful (2.57), trustworthy (2.57), credible (2.29), and accurate (2.86). These results are noticeably rated higher than the altered misinformed social media post that only included social engagements.

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
VA_RISERA_1	20	1	5	2.45	.285	1.276	1.629
VA_RISERA_2	20	1	4	2.35	.284	1.268	1.608
VA_RISERA_3	20	1	4	2.45	.312	1.395	1.945
VA_RISERA_4	20	1	4	2.10	.240	1.071	1.147
VA_RISERA_5	19	1	4	2.53	.280	1.219	1.485
VA_RISERA_6	19	1	4	2.32	.276	1.204	1.450
VA_RISERA_7	19	1	4	2.68	.276	1.204	1.450
VA_RISERA_8	19	1	4	2.47	.280	1.219	1.485
VA_RISERA_9	16	1	4	2.94	.309	1.237	1.529
VA_RISERA_10	16	1	4	2.88	.272	1.088	1.183
VA_RISERA_11	16	1	5	2.81	.319	1.276	1.629
VA_RISERA_12	16	1	5	2.88	.315	1.258	1.583
VA_RISERA_13	16	1	5	2.69	.326	1.302	1.696
VA_RISERA_14	16	1	4	1.75	.281	1.125	1.267
VA_RISERA_15	16	1	4	1.75	.281	1.125	1.267
VA_RISERA_16	16	1	4	1.88	.301	1.204	1.450
Valid N (listwise)	16						

Figure 5. Vaccines, Rate Influence of Social Engagements & Related Articles

Lastly, Figure 12 shows the results of combining the both treatments (i.e., social engagements, and related articles) to examine if multiple treatments are more effective in countering misinformation than just one treatment. When assessing the misinformed social media post itself, respondents found it to be relevant (2.68), which was more than those who rated it as providing new information (2.45), to be useful (2.35), trustworthy (2.10), credible (2.53), or accurate (2.32). The related articles were rated to be useful (2.94), which was more than those who rated the related articles as providing new information (2.47), to be interesting (2.88), trustworthy (2.81), credible (2.88), or accurate (2.69). Following the trend of the previous results to this study, the presence of social engagements (i.e., likes, comments) had a low rating for affecting personal beliefs about vaccines (1.75), in addition to the presence of likes and comments from the actual survey affecting beliefs about vaccines (1.75). Furthermore, the low-rated responses were consistent when respondents were asked whether an increase in social engagements would be more impactful in influencing personal beliefs on vaccines (1.88).

DISCUSSION AND CONCLUSIONS

The results from our study can reassure those who are seeking to develop effective ways of misinformation on social media platforms. Our experimental survey shows that perceptions towards the controversial topics of climate-change and vaccines are more influenced by the presence of related articles directly under misinformed social media posts than the presence of social engagements in the form of likes and comments.

Although the difference in response between social engagements and the related articles feature was small, it is noticeable enough to warrant further investigation by social media companies that are interested in curating content that is posted on their platforms. Furthermore, educational institutions can use this study to show students the importance of relying on validated news sources since the algorithms and human agents that social media companies use to curate their platforms may not be accurate 100% of the time. that show that the related articles feature had a greater impact than the presence of likes and comments when it came to influence the beliefs of respondents on controversial topics such as climate-change and vaccines.

In terms of social cognitive theory (SCT), this study does not appear to be in harmony with SCT's observation that people can learn new behaviors simply from observing others. We suspected that SMN users who saw the social endorsements in the form of likes and comments would have their perceptions influenced more in regard to their views on climate-change and vaccines. However, this was not the case. Respondents tended to reduce their perceptions about these topics after seeing the misinformed social media post, even with the presence of social endorsements.

Lastly, the Social Information Processing theory (SIP) that we used was found to be more in harmony with our study than SCT. SIP's three main components (sender, receiver, and feedback), were all present and clearly identified in our study that used the computer-mediated communication (CMC) tool of the simulated social media post. The sender came in the form of the misinformed social media post. Next came the receiver, who was the SMN users exposed to the misinformed social media post. Finally, the response of the SMN users to the misinformed social media post of the sender was measured as feedback. We believe that future studies and methods of social media platforms to mitigate misinformation may be interested in using SIP closely in order to measure the success of any campaign to counter the spread of misinformation on their a social media platforms.

As we mentioned earlier, most of the respondents were college students in their twenties, which was a limitation of our study. This could have possibly skewed the data since the college students may have been more knowledgeable about vaccines and climate-change in general. A larger and more diverse sample size would help to determine if this is really the case.

This study aimed to test whether the use of social engagements and related articles to influence the perceptions of SMN users exposed to misinformation on social media work better separately or in tandem. We chose to use the "related articles" feature because of its proven efficacy in previous studies along with the presence of social endorsements in the form of "likes" to influence the perceptions of SMN users about controversial topics.

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Using the Xbox Kinect to Correct Bowling Form

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ABSTRACT

In this paper, I propose an application that will correct the form of a bowler with poor form and increase their performance. The proposed approach that I will be taking is to use the Xbox Kinect sensor to capture the skeleton of a bowler from the side, instead of the front of the bowler. I will be capturing the skeleton of the bowler instead of the movement, which will allow one to assess and compare the form of the bowler more clearly and accurately. Which leads to why this approach will be successful, by capturing the movement of the skeleton itself instead of the movement of the body, we can provide better feedback on the form of the bowler. Thus, improving their form and performance.

Keywords—Kinect; Bowling form; Xbox One; Sensor; Human-Computer Interaction.

Introduction

When we go to bowling alleys, more often than not, we are often mesmerized by the one person who seems to get a strike with every swing. While the bowling ball you seem to keep throwing, ends up in the gutter and now for the next few days, you are the laughingstock amongst your friends. Being this poor at this sport can make playing it unpleasing, frustrating, and embarrassing due to you having to ask to have the rails put up to prevent you from getting constant gutter balls. The truth of the matter is that the form we use to bowl the ball can make a huge difference from getting a strike and getting a gutter ball. To have a better chance of getting a strike, you need to have the proper form to do so. People who have proper form when bowling, are more likely to bowl a strike, then someone who does not have the proper form. So now the question stands, how can we correct the form of a poor bowler?

To improve the form of a poor bowler, I utilized the Xbox Kinect senor V2 to help provide the necessary adjustments to correct a bowler's form. By using the sensor, I can capture and record the skeleton of a bowler and set up a virtual environment that provides the feedback needed to perfect their form. For this to be done, I needed to create the bowling gesture in Visual Gesture Builder provided by the Kinect SDK. I then needed to teach the sensor to detect this discrete gesture by recording the gesture in Kinect Studio. Then in Visual Gesture Builder, I tagged the gestures in each clip to begin teaching the sensor to recognize the gesture. To effectively detect the gesture, I had to split it up into three parts, Stance, Swing arm back, and Follow

through. By splitting the gesture up into these parts, I can take a complex gesture and simplify it to make the gesture easier to detect. Once the sensor was trained, I can now begin writing the code in visual studio that allows us to create an application that will detect the gesture and provide feedback to the user on their form.

To evaluate the effectiveness of the application, Sports Champion 2 for PlayStation 3 using the PlayStation eye and move controller was used to test the given feedback from the application. By measuring the number of strikes and spares the bowler is able to get in the game, it will provide evidence to see if the given feedback was able to improve the bowler's performance. Having this application successfully correct the form of a bowler with improper form. Will help those who wish to better their form in bowling at no cost. This will also show how powerful the Kinect Sensor is and that it is still capable of correcting a person's form.

To recap what was discussed in this section:

- Stating the problem of why having improper bowling form can have a negative effect on someone socially.
- A remedy to the problem, an application that can correct the form of a bowler with improper form and provide feedback was introduced.
- A proposed method of correcting the form of a bowler and utilizing the Kinect SDK to teach the sensor to recognize the gesture and creating an application that would provide the feedback needed to help perfect a bowler's form. Then using Wii sports bowling to assess the effectiveness of the application by the number of strikes the bowler can achieve based on the feedback the bowler was given.

Related Work Section

In current practices, Virtual environments are created, and the Xbox Kinect sensor is used to capture the movement of the user. By using software such as PrimeSemse OpenNI to interact with the Kinect sensor to calibrate it to detect the proper posture for a user [2]. Others have used the virtual environment and the Xbox Kinect to detect full-body movement instead of just upper body parts. They prompt the user to follow each task and provide visual feedback to the user on the necessary adjustments that need to be made to have the proper form when exercising [3].

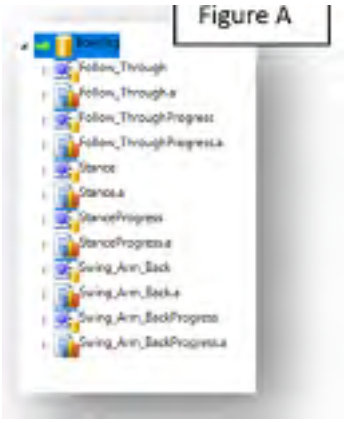
However, tracking motion via the Xbox Kinect sensor isn't the only way. The PlayStation move and PlayStation eye have been used to train users to become better golfers. The process involves mapping a PlayStation move controller to the shaft of the golf club and one to the head of the user. The PlayStation eye is then used to capture the movement and feed this information to the PlayStation 3 and then to the computer using a software called Move.me [4].

Though some use a more robust process to track the motion of users. In a recent study, researchers created a golf training system without the use of video game sensors to provide visual and aural feedback [1]. The approach that was taken was to fit the user in a tracking suit. Then project the shadow of the user onto the ground in real-time. Which provided visual feedback to the user on their form, while the golf club provided audio feedback to the user base on the golf clubs orientation.

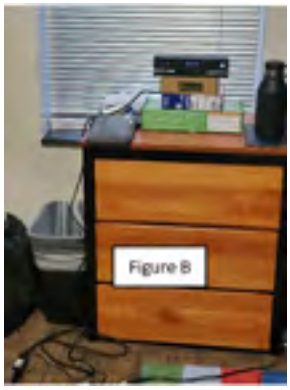
Proposed method

The proposed approach uses the Xbox Kinect sensor to capture the skeleton of a bowler from the side, instead of the front of the bowler. I will be capturing the skeleton of the bowler instead of the movement, which will allow me to assess the form of the bowler more clearly and accurately. Since the gesture that I am wanting to create is a complex gesture. It had to be split up into three gestures, that would be later stored in the bowling database - Follow Through, Stance, and Swing Arm Back (As shown in figure A). Breaking this gesture into parts makes it easier for the sensor to detect. To make sure that the sensor can detect the gestures, I needed to give it training data.

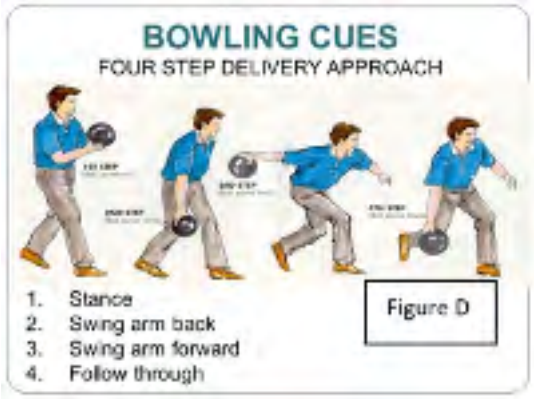
To do this, Kinect Studio was used to record the skeleton of a bowler with proper form. To record the skeleton of the bowler, the Kinect Sensor was placed 14 feet away from the bowler to ensure that the entire skeleton is

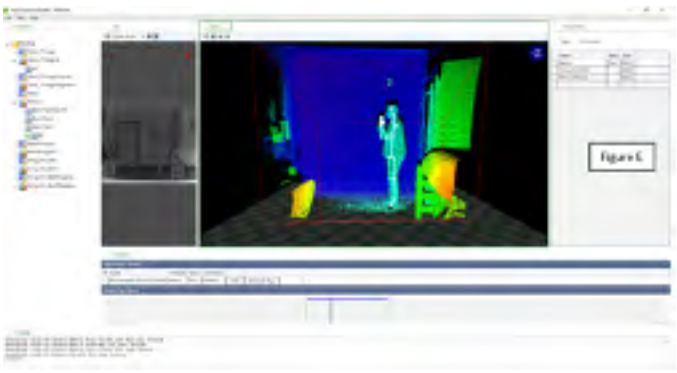


captured. (Figures B and C). As shown in Figure C, on the laptop, Kinect Studio is currently running, and I am able to render the body index of the bowler. Once the skeleton is being tracked, I can begin recording the skeleton of the bowler. When recording the movements of the skeleton, the following cues shown in Figure D were executed.



By following these cues, I can ensure that the bowlers are executing each gesture I am wanting to train the sensor to recognize. In Kinect Studio, bowlers with good form executed each cue they were told. Once all of the data from the bowlers with good form was recorded and saved. It was time to train the sensor to recognize the gestures. In the application Visual Gesture Builder, each training clip that was recorded in Kinect Studio was loaded into Visual gesture Builder (Figure E). For each respected gesture a clip was loaded and tagged, for example, in Figure D, I have the Stance gesture open, here I tagged a specific portion of the clip were the stance gesture is present. After each gesture has been tagged, different trial clips are then loaded into analysis (files ending in .a), where they are analyzed and the AdaBoostTrigger algorithm is ran against each clip to analyze, which gesture is present in the clip.





The solution is then built, which generates the bowling database file that is needed to create the application. Once the database file was generated from the Visual Gesture Builder, the application could now be built. The application that was created in C# was built off of the coding sample from the Kinect studio that help teach the users how to write code for the Kinect. Once the application was written, the application needed to be tested to test the effectiveness of the application. To evaluate the effectiveness of the application, Sports Champion 2 for PlayStation 3 using the PlayStation eye and move controller was used to test the given

feedback from the application. After each frame the bowler bowled, their score was recorded and compared to the pervious frame they had bowled when the corrector was not in use. After the bowler had finished their frames the data from their game was collected and analyzed to present the results.

Experimental Setups and Evaluations

When developing this application, the Kinect SDK was heavily was used to provide clarity on the Kinect library for writing code to interact with the Kinect sensor. When gather training data for the sensor, the application, Kinect Studio, was used. This application along with the Visual Gesture Builder can be found in the Kinect SDK along with coding samples, to help you learn how to write code for the Kinect. By installing the Kinect SDK, the drivers and necessary components for using the Kinect are also installed.

Before I could begin recording with sensor, an adapter is needed to connect to the Kinect and provide power to the sensor. I used the Xbox One Kinect Adapter for Windows Interactive APP Program Development, which allowed me to connect my computer to the sensor. Once the sensor was connected to my computer, I could begin setting up the environment to record. The sensor was placed four and a half off the ground (Figure B), then a marker was then placed 14 ft. away from the sensor to ensure that the entire body was captured in the frame. After the marker was placed the bowlers with good form were asked to stand on the marker and perform the cues previously mentioned in the proposed method section, they were also instructed to perform these cues facing forward to ensure the sensor captured the right side of the bowler and not the front. After the bowlers with good form had completed performing all the cues the clips were saved and inserted into the Visual Gesture Builder.

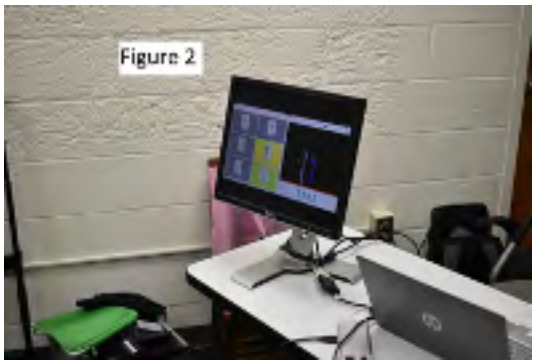
In Visual Gesture Builder, every clip that was recorded in Kinect Studio, is loaded into the application. Once the clips have been loaded, I had to go through each clip and tag the parts of the clip where the given gesture was present. After completing tagging each clip, I could begin building the solution where a .gbd file is generated, this is a gesture database file that has all of the gestures created in Visual Gesture Builder, which is the Stance, Swing Arm Back and Follow Through gesture.

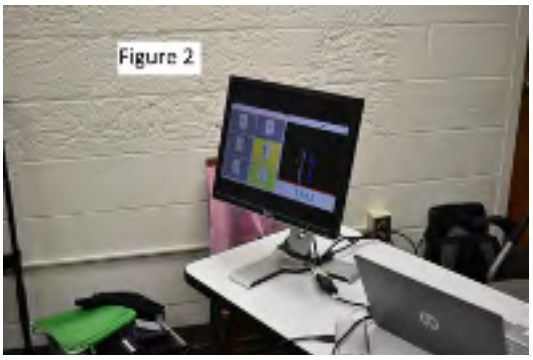
After the file is created, this file is then copied into the source folder in my code called Database. In this folder we place the .gbd file here so we can access it. Once that file is in the folder, I could begin writing my code to interact with the sensor. When developing this application, I utilized the Kinect SDK as a starting point to write the code to interact with the sensor. This helped in creating the KinectBodyView class that reads in the skeleton of a person entering the frame. Once the code for this application was complete, it was time to test the application.

When testing the effectiveness of the application, Sports Champion 2 for PlayStation 3 using the PlayStation eye and move controller was used. This game was chosen, because it was the most realistic to actual bowling that I could find in a game. I then asked the bowlers with bad form to come in to test the application.

The environment was set up as follows, The Kinect sensor was placed four and a half feet off the ground (Figure 1) and a marker was placed 14 ft away from the Kinect sensor which was placed to the right of the bowler.

The game was placed on a table and the bowlers stood 3ft away from the PlayStation eye camera (Figure 3). Monitor was also set up beside the game so the bowlers could see their form and feedback in real-time. (Figure 2)



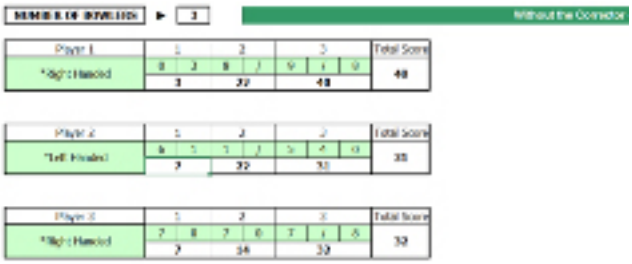


The bowlers with poor form were asked to play two games of bowling with the difficulty level set to championship, this increased the sensitivity of the move controller and removes all help that prevents the ball from going into the gutter. The first game they played involved them playing the game without the

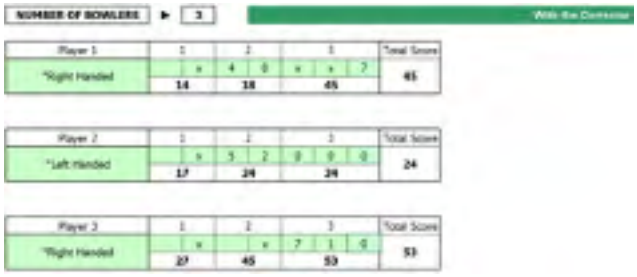
corrector to assess how they bowl without the corrector. The second game they played involved the corrector, during this game they had to follow all of the cues the bowlers with good form followed, and the application provided feedback on what they needed to change. After the end of each frame of the second game, their scores got recorded and then compared to how they did in the previous frame of the first game. Once the second game concluded the data was saved to do further analysis of the scores.

RESULTS AND DISCUSSION

When the testing the effectiveness of the application two trial runs were attempted in the first trial run the bowlers were asked to play two games that consisted of 3 frames. During this first trial, it consisted of 3 players all male, whose ages ranged from 19 to 21. After the first game these where the results:



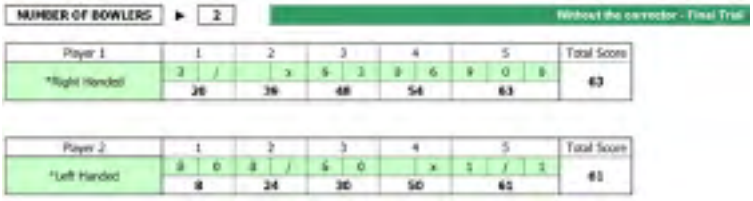
As you can see from the scores above that no one in this first trial was able to get a strike and they had a hard time trying to get spare as well. However, there was a drastic change in these scores once the corrector was used in the second game.



In the scores above we can see the players were able to get strikes in this second game using the corrector. Both player 1 and 3 had an improvement in their scores thus concluding that the corrector improves their performance. However, this cannot be said about player 2. Player 2 was left-handed and was asked to play both games using their right hand, which was there least dominant hand. This caused the outcome to be different for them, because in the first game they are able to create a form that was comfortable for them to bowl. But, in the second game that form was being corrected and they had to relearn how to bowl using their

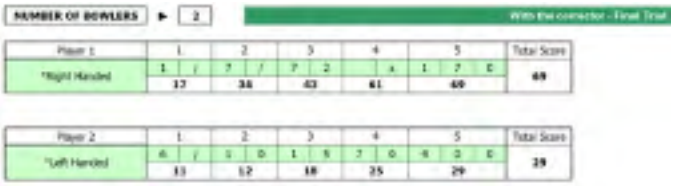
right hand, causing the outcome to be different from player 1 and player 3.

To verify the results of the first trial a second trial was conducted. In this trial, it was conducted the same as the first trial, but the players had changed, and the number of frames. 2 players were asked to participate one male (60) and one female (23). They were asked to play two games of bowling that consisted of 5 frames. After the first game had concluded these were the results:



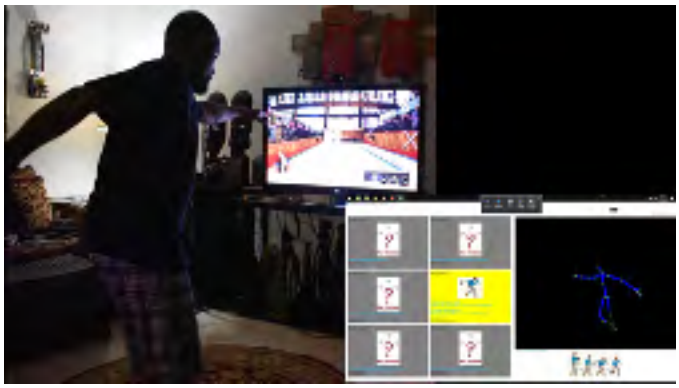
NUMBER OF BOWLERS ▸ 2																Without the corrector - Final Trial
Player 1	1		2		3		4		5							Total Score
*Right Handed	3	/		x	5	1	0	6	9	0	0					63
	20		39		48		54		63							
Player 2	1		2		3		4		5							Total Score
*Left Handed	0	0	0	/	6	0		x	1	/	1					61
	0		24		30		50		61							

From the results shown above we can see the players were able to get strikes and overall do well in the first game. However, similar to the first trial, once the corrector was introduced there was divide in the results once again.



NUMBER OF BOWLERS ▸ 2																With the corrector - Final Trial
Player 1	1		2		3		4		5							Total Score
*Right Handed	1	/	7	/	7	2		x	1	7	0					69
	17		36		45		61		69							
Player 2	1		2		3		4		5							Total Score
*Left Handed	6	/	1	0	1	5	7	0	0	2	0					29
	13		12		18		25		29							

The scores above are the results from the second game once the corrector was used. Based on the results, we can see that Player 1's performance improved, by seeing that they were able to knock down more pins from the feedback given. Player 2 (shown in the image below) was similar to the outcome of player 2 in the first trial, both were left-handed and struggled using their right hand to bowl. As a result, as they begin getting feedback on their form in the second game they had to relearn how to bowl and get accustom to using their right hand.



What effected the reuslts of the players who were left handed was the training data given to the sensor. All of the bowlers with good form were right handed and the sensor was recording them from their right side. So, when bowlers who were left handed used the corrector, they got different results from other players. Left-handed players had to use their right hand to use the corrector, because if they used their left-hand the Swing Arm Back gesture was never detected. I believe that if I had a second sensor when capturing my data and running the trials, the outcome for bowlers who were left handed would've been different.

Conclusions

To recap, the proposed application introduced in this paper, utilized the Xbox Kinect sensor to capture the skeleton of a bowler, then provide feedback on their form to increase their performance. This was accomplished by, utilizing the Kinect SDK to train the Kinect sensor to detect the bowling gestures, to provide feedback on a bowler's form. This application was then tested by conducting 2 trials, where participants played Sports Champion 2 for PlayStation 3 using the PlayStation eye and move controller to perfect their form. The end result of this was an application that improved the form a bowler with poor form and increased their performance.

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How Ethnicity acts as a Moderator for Parental Style, Adolescent Well-being, and Academic Self-efficacy and Interest

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ABSTRACT

To close the academic achievement gap, further research needs to be done to understand how to help students achieve in school. We investigated the associations between parental style, negative adolescent characteristics, and adolescent academic self-efficacy and interest. To investigate these associations, archival data from the Panel Study of Income Dynamics was analyzed. In this study, all families lived under the poverty level and the parents reported their parenting style and behaviors of their children. Academic self-efficacy and interest levels were reported by 816 adolescents. It was found that the presence of negative adolescent characteristics leads to lower levels of adolescent self-efficacy and interest in academics. It was also found that high parental warmth leads to higher levels of self-efficacy in math for both European American and African American adolescents. The associations between parental style, adolescent well-being, and adolescent self-efficacy and interest also differed by ethnicity. Based on these findings, parents can incorporate positive parenting techniques to help students gain higher levels of academic self-efficacy and interest.

Keywords: academic achievement gap, parental style, internalizing, externalizing, self-efficacy, ethnicity, African American, European American

The academic achievement gap has been and remains an issue in the United States, especially between European Americans and African Americans. The achievement gap refers to the difference in academic achievement between those with minority and majority cultural backgrounds, often unfavorable to minority groups. This gap exists due to the lack of resources supplied to children and adolescents who are part of lower-income communities (Sirin, 2005). These lower-income communities primarily consist of minority families. Without the proper resources, obtaining an education becomes a difficult task. Also, other negative external factors influence a student's ability to achieve well in school. These factors can include a parenting style that may not be ideal or an adolescent's negative behaviors (Pinquart, 2017). A lower-income status reflects more than money; it also reflects other factors such as neighborhood quality, health and diet, and access to mental health services. All of these factors play a role in how a child develops and the opportunities afforded to them. When comparing the achievement levels of adolescents who come from a low-income background versus a higher-income background, the similarities in learning standards do not matter if the vast amount of challenges those in the low-income background face are not considered.

To close the academic achievement gap, the many factors contributing to it must be examined. This means identifying the possible relationships that may exist among income, ethnicity, parental style, adolescent characteristics, and achievement. This study aims to further knowledge about academic achievement and its contributing factors in hopes of identifying the relationships among them, specifically by examining the relationship between parental style, adolescent well-being, and academic self-efficacy and interest. In the remainder of the introduction, I discuss the theory of self-efficacy, academic interest, and overall academic performance. While doing so, I highlight the importance of using positive parenting techniques to increase adolescent academic performance. Then I show how parenting techniques could lead to specific adolescent characteristics. I also provide reasons to believe that ethnicity moderates the association between parenting techniques and adolescent behaviors.

Self-Efficacy and Academic Performance

According to self-regulation learning theory, self-efficacy is a necessary step on the way to academic success. Self-efficacy may be considered a type of academic success. The concept of self-efficacy was developed by Albert Bandura (Bandura, 2008). He theorized self-efficacy to be a person's belief of how well they could achieve or accomplish a task or goal. Many researchers have found self-efficacy to be a key factor in improving performance, especially in academics (Yokoyama, 2019). Those who have higher levels of self-efficacy are more likely to have higher academic performance than those with lower levels of self-efficacy. Self-efficacy involves evaluating one's self and abilities and using that evaluation to determine how likely it is to be able to complete a task. Because self-efficacy involves evaluating one's self, it can be influenced by factors such as direct encouragement from parents (Yokoyama, 2019). If a parent has confidence that their

child can achieve in school, the child will have confidence that they can achieve in school. Self-confidence, unlike global self-esteem, is task-specific. A child can have good deal of self-efficacy for one task and have a relatively weaker sense of self-efficacy for another.

Self-efficacy levels can be improved by practicing one of the following methods: mastery experiences, social modeling, social persuasion, or states of physiology (Bandura, 2008). Mastery experiences involve recognizing the importance of a goal and attempting to reach the goal by examining failures and learning from them. In an academic setting, a student may recognize that they have failed at a certain task and learn from that failure. Reflection on the failure can produce higher levels of self-efficacy.

Bandura's method of developing self-efficacy stems from the theory that behavior is a result of observation. Social-modeling involves identifying an individual who is similar in some way and has succeeded, thus believing you have the ability to succeed as well. For students trying to achieve in academics, this can be done by observing someone close to them succeed in academics. For example, an adolescent who watches her parents enjoy reading and engaging in academic activities with confidence will be more confident herself at school than an adolescent who watches her parents struggle, avoid, and dread academic activities.

Similarly, social persuasion is done by having a positive influence but in a more direct manner, such as a mentor (Bandura, 2008). An individual who can encourage and provide constructive ways to improve would be ideal for a child attempting to improve academic achievement. For example, a child who is encouraged to study by her parents will be more confident in school than a child who is told studying is unimportant by her parents.

Lastly, Bandura believed that self-efficacy is related to an individual's physiological state. An anxious individual will have a difficult time developing their self-efficacy levels, so improving and finding ways to get rid of negative emotions or thoughts, will allow individuals to then improve their self-efficacy levels. Recognizing and changing these negative emotions can be difficult but is done through introspection and being kind to oneself (Bandura, 2008). Any of these four methods will improve self-efficacy levels and this can influence many aspects of an individual's life.

With the theory of self-efficacy, academic performance becomes about more than one's knowledge and skillset. Another construct of academic performance is the interest the student has in the task or subject they are doing. Academic interest can be used to predict a student's academic performance (Steinhoff & Buchmann, 2017). When a student is interested in the subject, their level of motivation and belief in their success increases. For this reason, self-efficacy and interest are linked in predicting how well a student can achieve in school. Previous research has found self-efficacy and interest to have a reciprocal relationship, where an individual may have a high level of self-efficacy as a result of a higher level of interest and vice

versa (Nuutila et al., 2020). Therefore, helping adolescents gain confidence in themselves and their ability to succeed can prove to be a successful way to increase their academic interest and improve academic achievement levels. Helping students do so requires using one of Bandura's methods, which can be done through specific parental techniques and positive parental behaviors.

Parenting Style Predicts Adolescent Self-Efficacy

Parental style predicts adolescent performance in school and can often be a determining factor in whether an adolescent succeeds or fails in academics. Parental style reflects the choices made to discipline and socialize a child (Doinita & Maria, 2015). Child development is often a reflection of the parental style used. There are pros and cons to each of the different parental styles, which can be broken down into four types.

Diana Baumrind identified the four parenting styles to be authoritarian, permissive, uninvolved, and authoritative. Parenting styles are usually looked at through two dimensions: demandingness and emotional responsiveness (Baumrind, 1991). Each dimension is independent of the other. A parent can display a high degree of one dimension while displaying a low degree of the other dimension. A parent can also display a low degree of both dimensions or a high degree of both dimensions. Authoritative parenting involves high demandingness and high emotional responsiveness which typically means the parent sets clear expectations and rules but also shows high levels of emotion and warmth (Matejevic, Jovanovic, & Jovanovic, 2014). Authoritarian parenting involves high demandingness and low responsiveness which typically means the parent sets clear expectations and rules but shows low levels of emotion and warmth. Permissive parenting involves low demandingness and high levels of responsiveness which means the parents set no expectations and rules but show high levels of emotion and warmth (Matejevic, Jovanovic, & Jovanovic, 2014). A permissive parent often thinks of herself or himself as a friend to the child. Uninvolved or neglectful parenting involves low demandingness and low responsiveness which means the parent sets no rules and shows the child no warmth. In terms of healthy child development, authoritative parenting is considered to be the ideal style (Matejevic, Jovanovic, & Jovanovic, 2014; Warren, Locklear, & Watson, 2018). Those parents who use an authoritative parenting style (e.g., sets and enforces rules) often report high levels of academic success and lower levels of internalizing problems and externalizing behaviors in their children (Bester & Malan-Van Rooyen, 2015).

A parent's ability to express their own emotions and behavior is an important part of their parenting style. Often, the children will imitate how their parents express their behavior and emotions. For example, when parents express little to no control over their behaviors, the child will imitate the parent and also not control their behavior. It has been found that children who are raised in low-income households are more likely to imitate the out of control expressions of emotion of their parents than children raised in affluent households. Being able to regulate emotions is a skill that is not only vital in childhood, but also later in adulthood. This

finding is specifically shown in lower-income households, and not statistically significant in households with higher income. Knowledge of why this difference exists is still being researched.

Parenting style can be associated with the socio-economic status of the household. For example, Nishina and Bellmore (2018) state that children in higher socioeconomic status families are allowed more freedom than those in the lower. The parents in the higher socioeconomic status are often referred to as less strict than an authoritarian parent would be (Nishina & Bellmore, 2018). Likewise, parents who are non-authoritative tend to not be engaged in anything school-related pertaining to the child, resulting in the child having lower school achievement. Nishina and Bellmore (2018) found that adolescents who had parents that demanded positive behaviors and set clear expectations were more likely to do well in school and surround themselves with positive peers. The opposite effect takes place when the parents have no expectations or demands of behavior and achievement.

In sum, considering the ways self-efficacy can be developed or improved, the parenting style a parent uses can either help or obstruct an adolescent's self-efficacy levels. An adolescent whose parents are positive and express their emotions healthily is likely to do the same or have an easier time with using one of Bandura's methods of improving self-efficacy. Those adolescents who do not receive warmth and are shown a negative display of emotions are likely to have both lower levels of self-efficacy and have a more difficult time using one of Bandura's methods of improving self-efficacy. The behaviors an adolescent is exposed to and the characteristics an adolescent has are important in the development of self-efficacy, and self-efficacy is important in the development of academic achievement.

Adolescent Behaviors and Emotions Influence Academic Performance

The ability to control behaviors and self-regulate emotions are key factors in successful development (Perry et al., 2018). Negative adolescent characteristics often present in two ways: internally or externally. Internalization refers to negative emotions being expressed inward by the individual and can result in that individual being anxious, afraid, or worrisome. Externalizing behaviors do the opposite and are expressed outwardly, resulting in an individual who argues, bullies, or is physically aggressive. These characteristics can develop in an individual due to many factors, including stress, and can hinder overall adolescent well-being.

Well-being refers to an individual having a positive, happy, content life. The environmental influence on a child's well-being is crucial for all children. The environment has a lot of influence, if not more than genetics on the child's development. The difference lies in the environmental inconsistencies among children in different ethnic and socioeconomic groups. The environment, such as the neighborhood, that the adolescent grows up in shapes how they respond to different social situations. Schibli, Wong, Hedayati, and D'Angiulli (2017)

found that children in lower-income households are susceptible to a more chaotic environment, increasing their likelihood of chronic stress and decreasing their chance of having a healthy childhood development. Nishina and Bellmore (2018) argue that children who grow up in neighborhoods with similarity in terms of race and socioeconomic status, learn to adapt to that environment. Therefore, children in lower-class status neighborhoods are more likely to develop an ability to deal with threats to their safety and develop traits that allow them to better adapt to their situation. Traits such as anxiety and anger are not uncommon in children who are in these environments due to what they experience. Turley's (2003) study looked at how the neighborhood a child lived in affected test scores, self-esteem, and behavior. The results showed that the type of neighborhood the child lived in impacted test scores, self-esteem, and behavior positively if the child was white in a higher income neighborhood (Turley, 2003). The many stressors minority adolescents face ultimately influence their development. While the ethnicity of a student is not a predictor of how they are expected to perform, the implications of their ethnicity can influence their self-esteem and behavior, especially for minority adolescents.

Considering how the environment (e.g., parent style, parent behaviors, socioeconomic status) can influence the characteristics an adolescent has, it's role should be examined in how it influences an adolescent's ability to develop higher self-efficacy levels. Bandura claims self-efficacy is something every individual has and can be developed despite negative conditions a person may be going through. The differences in environment, therefore, should not influence self-efficacy levels and academic achievement, but the academic achievement gap shows how these differences in environment cause disparities, especially among European and African American ethnicity groups.

The Role of Ethnicity in Parental Style and Adolescent Behavior

While income plays a role in the parenting style used in the family and the behaviors adolescents express, ethnicity is involved as well. Being a minority adolescent is associated with many challenges. Adolescents raised by parents who identify with a minority culture (e.g., African American or Latinx American) are more likely to face financial and educational hardships than adolescents raised by parents who identify with a majority culture (e.g., European American). Adolescents from a low socio-economic and minority ethnic background face many obstacles, especially in development and achievement. To combat the consequences of such environments, it is typical for parents to use harsher parenting techniques (Julian, McKenry, & McKelvey,1994). An authoritarian parenting style may have benefits when living in a risky environment, as families from lower SES groups often do. For reasons such as guaranteeing survival, parents may adopt a parenting style more focused on demandingness rather than warmth (Kelley, Power, & Wimbush, 1992). This may explain why the relationship between authoritative parenting techniques are not always positively associated with academic achievement among African American and Latinx American adolescents (Turner,

Chadler & Heffer, 2009). These differences are important, especially when attempting to understand ways to help adolescents succeed academically.

In many instances, academic disparities are due to the lack of resources given in low-income and minority communities. Science, Technology, Engineering, and Math (STEM) programs have been identified as a positive tool in increasing academic achievement but have a lack of participation from African American adolescents. While there may be a lack of participation, there is also decreased funding to implement STEM programs in schools with high populations of African American students (Crabtree, Richardson, & Lewis, 2019). When there is a lack of participation in extra-curricular activities or programs focused on subjects such as STEM, those individuals are not able to reap the rewards these programs give, such as scholarships and better education opportunities. School activities have proven to be very beneficial for the well-being of students (Dearing et al., 2009). When students have the opportunity to participate in sports or art activities, they have the chance to develop positive social traits, an important part of well-being.

Afterschool activities help individuals find their passions and develop their interests and talents. To not afford all students the opportunity to do so, creates a disadvantage for those without the resources to participate. An individual's socioemotional development heavily depends on the environment they are exposed to and can be developed through many afterschool activities such as art, music, sports, tutoring, etc. However, these afterschool activities are mainly present in the middle-high socioeconomic status population because they have the knowledge and resources to identify how such programs positively influence their children (Aranha, 1997). According to Dearing et. al (2009), factors such as the cost of these beneficial programs, and the availability of them should be considered among the context of adolescents in the lower socioeconomic status. Not only is there a scarce chance to have programs such as music or art classes in this area, but there is also the high cost that prevents many adolescents from being able to participate.

These disparities show the extent of how different outcomes can be due to ethnicity and income. Ethnicity modifies the association of adolescent characteristics and parental style with academic self-efficacy. This is because of the overwhelming amount of resources and privileges available to majority status students (e.g., European American) and the lack of resources available for minority status students (e.g., African American). However, research can help identify the advantages and disadvantages of certain parenting techniques and find intervention methods to counter the vast adversities those in the low-income and African American households experience.

Current Study

The purpose of this study is to further research on how self-efficacy can be used to increase academic achievement. The academic achievement gap remains an issue for those in the minority and low-income populations. There are an abundant amount of students in minority and lower SES groups suffering because of factors outside of their control. To understand how the adolescent's environment influences the adolescent's ability to develop their self-efficacy levels, preventative measures can be identified to combat some of the environmental influences students are impacted by. Also, this study will look at the adolescent's level of academic interest to identify an additional way to predict academic achievement. Acknowledging the different parenting styles that families in different ethnicity groups use may identify what factors (demandingness and responsiveness) parents are expressing high or low in. With this knowledge, suggestions can be made to address the pros and cons of each parenting style. Once the associations between adolescent characteristics and school achievement levels are identified, new teaching methods and incentives for adolescents who are having a more difficult time due to external factors can be used.

This study has four hypotheses:

1. Negative adolescent characteristics will be negatively associated with adolescent academic self-efficacy levels and academic interest levels.
    a. Internalizing problems will be negatively associated with adolescent academic self-efficacy levels and academic interest levels.
    b. Externalizing behaviors will be negatively associated with adolescent academic self-efficacy levels and academic interest levels.
2. Parental punishment will be negatively associated with academic self-efficacy and the academic interest levels in adolescent(s).
3. Positive parent techniques will be positively associated with academic self-efficacy and the academic interest levels in adolescent(s).
    a. Warmth will be positively associated with academic self-efficacy and the academic interest levels in adolescent(s).
    b. Rule setting will be positively associated with academic self-efficacy and the academic interest levels in adolescent(s).
4. The associations between parental style, adolescent well-being, and academic self-efficacy levels will differ by ethnicity.

METHOD

Participants

Participants were 816 adolescents, aged 13 - 18. Of these adolescents, 372 were African American (AA) and 444 European American (EA). The participants were representative of the demographics of the United States, with an emphasis on only selecting participants who were living under the poverty level.

Procedure

This study used a database from The Panel Study of Income Dynamics. The Panel Study of Income Dynamics (PSID) longitudinal study included a child development supplement (2014) and took place at the University of Michigan's survey research center. This supplement aimed to collect data on a broad range of topics including child/adolescent health, development, and well-being. This supplemental study also included responses from families who completed a previous PSID (2013) interview and had children in their household. Researchers collected questionnaires from the participants via phone and in-person interviews (Panel Study of Income Dynamics [PSID], 2014). The primary caregiver (PCG) in each participating household answered the questionnaire concerning their parenting strategies and their child's behavior and well-being. The adolescent participants answered questions concerning their ability in school. The study has been approved by the Institutional Review Board at the University of Michigan. The data collected during the study are made available on the Panel Study of Income Dynamics website and are free for students and researchers to use. To fit the data to this study's aim, specific variables were selected and analyzed.

Measures

Adolescent Behaviors and Emotions

Internalizing. The primary caregivers (PCGs) rated how sad, lonely, anxious, and depressed their adolescent child was (e.g., "he/she is withdrawn and does not get involved with others"). This scale included eight items. PCGs used a 3-point scale ranging from 1 (often true), 2 (sometimes true) to 3 (not true) to provide their ratings. An average internalizing scale was calculated by averaging the eight items together. The reliability for the scale was $\alpha = .80$.

Externalizing. PCGs rated how true it is that their adolescent child outwardly expresses their negative emotions (e.g., "he/she breaks things on purpose or deliberately destroys his/her own or another's things"). This scale included 8 items on a 3-point scale from 1 (often true), 2 (sometimes true) to 3 (not true). An average externalizing scale was calculated by averaging the eight items together. The reliability for the scale was $\alpha = .81$.

Parental Behaviors

Parental Punishment. PCGs reported how often they disciplined their child (e.g., "how many times have you taken away privileges"). This subscale included five items, indicating the number of times in a week they disciplined their adolescent. The reliability for the scale was α = .66.

Parental Warmth. PCGs reported how often they used warmth as a parenting strategy (e.g., "how often do you show physical affection") during a typical week. Three items were included in this measure and an average parental warmth score was calculated by averaging the three items. The reliability for the scale was α = .71.

Rule setting. PCGs reported how often they set and enforced rules (e.g., "do you have rules about afterschool activities"). This subscale included five items, with a 4-point scale ranging from 1 (yes, there are clear rules and they are enforced), 2 (yes, there are general rules and they are monitored), 3 (yes, there are rules, but child makes own choices) to 5 (no). An average rule-setting scale was calculated by averaging the five items together. The reliability for the scale was α = .78.

Academic Achievement

Math Self-efficacy. Adolescents reported their confidence in doing math problems (e.g., "how good at math are you"). They rated their confidence on a 5-point scale ranging from 1 (not at all good), 2 (somewhat not good), 3 (ok), 4 (somewhat good) to 5 (very good).

Math Interest. Adolescents reported their interest in doing math problems (e.g., "how do you find math assignments"). They rated their interest on a 5-point scale ranging from 1 (very boring), 2 (slightly boring), 3 (somewhat interesting), 4 (moderately interesting) to 5 (very interesting).

Reading Self-efficacy. Adolescents reported their confidence in doing reading problems (e.g., "how good are you at English"). They rated their confidence on a 5-point scale from 1 (not at all good), 2 (somewhat not good), 3 (ok), 4 (somewhat good) to 5 (very good).

Reading Interest. Adolescents reported their interest in doing reading assignments(e.g., "How do you find working on English assignments"). They rated their confidence on a 5-point scale from 1 (very boring), 2 (slightly boring), 3 (somewhat interesting), 4 (moderately interesting) to 5 (very interesting).

Data Analysis Plan

The data for this study was archival data from the Panel Study of Income Dynamics (University of Michigan, 2019). The purpose of the study was to find similarities and differences in the association between parenting strategies, adolescents' psychological characteristics, and academic achievement among African American and European American youth. To achieve this, data analysis proceeded in two steps. In the first step, correlations among the study variables were calculated for the entire sample and then for two subsamples of youth: African American and European American youth. In the second step, the correlations for the two subsamples were compared using z-scores.

RESULTS

Correlations

Table 1 displays the correlations between the parenting variables and the youth's psychological variables, on the one hand, and the academic outcome variables, on the other. This table considers the entire sample as a whole. As can be seen, internalizing and externalizing were negatively associated with academic competence, and this is consistent with hypothesis 1. Also, parental punishment is most consistently predictive of low math self-efficacy levels and this is consistent with hypothesis 2.

Table 1

Correlations among Study Variables for the Entire Sample

	Math Self-Efficacy	Math Interest	Reading Self-Efficacy	Reading Interest
Internalizing	-.17*	-.11*	-.11*	.00
Externalizing	-.10*	.00	-.14*	-.08
Parental Punishment	-.11*	.03	-.04	.03
Warmth	.02	-.08*	.00	.01
Rule Setting	.05	.02	-.06	-.04

Note. N = 816, * p < .05

Tables 2 and 3 display correlations between the parenting variables and the youth's psychological variables, on the one hand, and the academic outcome variables, on the other. However, Tables 2 and 3 display the correlations for African American and European American families respectively. A visual inspection of these correlations reveals that there are some apparent consistencies between the two cultural groups and there are apparent differences. This visual inspection, however, needed to be confirmed by a statistical comparison of the correlations.

Table 2

Correlations among Study Variables for Participants of African American Heritage

	Math Self-Efficacy	Math Interest	Reading Self-Efficacy	Reading Interest
Internalizing	-.16*	-.07	-.14	.06
Externalizing	-.06	.02	.02	-.01
Parental Punishment	-.12*	.01	-.07	.02
Warmth	.11*	-.01	.01	-.09
Rule Setting	.08	.04	-.04	-.04

Note. n = 372, * p < .05

Table 3

Correlations among Study Variables for Participants of European American Heritage

	Math Self-Efficacy	Math Interest	Reading Self-Efficacy	Reading Interest
Internalizing	-.19*	-.12*	-.07	-.04
Externalizing	-.14*	-.06	-.16*	-.16*
Parental Punishment	-.10*	-.03	-.02	-02
Warmth	-.05	-.07	.02	.10*
Rule Setting	.02	.11*	-.06	-.02

Note. n = 444, * p < .05

Comparison of Correlations

A series of z-score tests were conducted to test whether the correlations found for two cultural groups, African American and European American families, were statistically different from one another. Table 4 presents the results of those tests. As can be seen, there are several notable similarities between the two groups. Internalizing is a consistent predictor of poor academic interest and self-efficacy for both groups. In addition, a parenting style that emphasizes punishment was a predictor of poor academic performance for both groups. Despite these similarities, there were also differences. For instance, parental warmth was predictive of math self-efficacy for African American families, whereas this association was not significant for European American families. Furthermore, externalizing was predictive of reading self-efficacy and interest for European American families, whereas this association was not significant for African American families.

Table 1

Correlations among Study Variables for the Entire Sample

	Math Self-Efficacy	Math Interest	Reading Self-Efficacy	Reading Interest
Internalizing	0.44	0.72	-1.00	1.42
Externalizing	1.15	1.14	2.57**	2.15*
Parental Punishment	-0.29	0.57	-0.71	0
Warmth	2.28*	0.85	-0.14	-2.70**
Rule Setting	0.85	-1.00	0.28	-0.28

Note. African American families, n = 372; European American families, n = 444

*p < .05. **p < .01. ***p < .001

DISCUSSION

The present study predicted there would be a negative association between negative adolescent characteristics and adolescent academic competence. As hypothesis 1a and 1b predicted, adolescent's self-reports of internalizing problems and externalizing behaviors were negatively associated with math self-efficacy, interest in math, and reading self-efficacy. Following hypothesis 2, there was a negative relationship between parents who used punishment and adolescent self-efficacy levels. It was also predicted that positive parent techniques would have a positive association with adolescent academic competence. As hypothesis 3a predicted, there was a positive relationship between parents who used warmth and adolescent self-efficacy levels. Additionally, as hypothesis 3b predicted, there was a positive relationship between parents who set rules and adolescent academic interest in math. These relationships differed slightly when looking at a specific ethnicity, which was the prediction of hypothesis 4. For example, while internalizing problems and externalizing behaviors negatively influenced academic competence overall, externalizing was particularly negatively associated with the academic competence of European Americans. Likewise, parental warmth had a positive relationship with the math self-efficacy levels of African American adolescents but a positive relationship with the reading interest of European American adolescents.

Consistent with previous research, these findings show the importance of parental techniques and their effect on adolescent well-being, as well as an adolescent's belief in how well they can succeed academically (Nishina & Bellmore, 2018). Often, the techniques a parent uses will reflect their well-being and can influence a child's behaviors and emotions. Therefore, those parents who are using positive parenting techniques (e.g., showing the child praise) are more likely to report their adolescents with less internalizing and externalizing traits and

higher levels of self-efficacy. The opposite can be found when parents use punishment techniques (e.g., sending the child to their room). With Bandura's theory of self-efficacy, all of his methods of developing self-efficacy levels included focusing on the positive and continuing the task or goal without negative thoughts or negative emotions (Bandura, 2008). Whether parents are aware or not, when they use positive techniques, they model the positive behaviors Bandura would say help individuals develop their self-efficacy.

The relationship between parental style, adolescent well-being, and adolescent academic self-efficacy and interest levels differed by ethnicity, which implies that some challenges may hinder the development of self-efficacy levels. These differences may exist because of cultural differences among the two ethnicities studied and if so, should be considered when attempting to explain why some techniques are used and others are not. These differences can also be a reflection of the patterns of disparity that have existed for years, negatively influencing African Americans. Often these disparities result from a lack of resources. (Dearing, 2009). Despite the challenges African American families may face, positive parental techniques can be incorporated to help students succeed academically.

Implications

Understanding the relationship between internalizing, externalizing, and academic competence, helps to identify the importance of being able to work through one's negative emotions and behaviors. Not being able to work through one's negative emotions can prove to be a challenge when older, thus finding ways to help adolescents do so before becoming adults, would be rewarding. For many children, understanding one's emotions and how to properly express them is learned from observing those around them. If a child has a parent who does not healthily express their emotions, the child is likely to adopt that same behavior, which in the form of internalizing and externalizing, can lead to lower academic achievement. Therefore, parents who are interested in preventing or intervening in their child's internalizing problems and externalizing behaviors should adopt positive parenting techniques (e.g., reward positive behavior). The use of positive parenting techniques models a parental style with a high level of warmth. When parents also have a high level of demandingness, such as setting rules, the parental style becomes authoritative and is known to predict great outcomes in children and adolescents (Bester & Malan-Van Rooyen, 2015).

The difference in relationships amongst African American families and European American families can help identify the importance of cultural differences when it comes to parental style. All of the families in this study were from a lower-income background, but the associations between factors were different, suggesting there may be more to the relationship than can be identified. To address findings relating to parental style, there must first be an understanding of how different cultures use or do not use parenting techniques. It is not uncommon for African American parents to use punishment techniques (Kelley, Power, & Wimbush, 1992). The purpose behind doing so may be in response to both past and current challenges the African American community face.

Therefore, suggesting to parents that punishment techniques are unhelpful, is ignorant to the reality of why many African American parents may choose those techniques. Instead, this study suggests the importance of positive parental techniques, whether its modeling positive behavior or giving praise. By focusing on the positive techniques and adjusting suggestions based on cultural differences, research on how to get rid of the academic achievement gap can prove to be more respectful and helpful.

Limitations

There are limitations in this study. Due to this study being a correlational design, it is difficult to make causal predictions. Therefore, other factors not considered could influence the relationship between the studied variables. This study also only looked at parenting and individual characteristics. Many other factors contribute to academic achievement so it cannot be assumed that using positive parenting techniques will guarantee better adolescent academic competence.

Future Directions

Future research could use a longitudinal design to better predict the relationship between the variables and also identify other moderators. The study could aim to answer the same research question, identifying what factors play a role in academic performance and how ethnicity may modify the relationship. For example, participants of varying ethnicities and income levels could be selected to observe over many years to detect changes in academic self-efficacy levels as a child goes through elementary, middle, and high school. This study would increase our knowledge of both cultural differences in parental techniques and the outcome of varying self-efficacy levels. Also, examining middle-class and upper-class families could help to identify how the relationship between the studied variables may change based on income. Doing so would help identify how to implement changes regarding the academic achievement gap in all areas, rather than those most accessible. If all the variables (child characteristics, parenting variables, and academic outcomes) are collected at each assessment point (i.e., a panel design), it would be possible to discern the probable causal order of the variables by using a cross-lagged statistical analysis. Thus, a panel design combined with a cross-lagged statistical analysis makes it possible to address the major limitation of this study.

Conclusion

This study examined two main factors that can attribute to success in school: parental style and adolescent psychological characteristics. To help families struggling with these factors, we must first understand how the relationship works with academic achievement and how to best intervene with respect for cultural differences that may be the reason for particular parental techniques. Thus, the focus of this study is only the beginning and further research should be done to close the academic achievement gap.

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Alternative Transportation Needs of Older Adults

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This paper aims to provide an overview of the current transportation needs of older adults in contemporary society. The literature examines transportation studies completed in early

1990 to 2020; as older adults' cessation of driving is a particularly modern problem due to spatial fragmentation, migration, and higher life expectancy. It analyzes the current practices provided by state and individual parties to showcase the need for more research in the area. Alternative transportation is essential for older adults to remain active, engage participants in society. The consequences of lack of transportation options will continue to increase negative outcomes for older adult individuals. The paper also provides narrative on the effects of lack of transportation access has on communities and service providers.

Keywords: older adults; transportation; social isolation; aging; social inclusion; ride-share services

In the 21st century, society has made great progress in advancing the quality of life of individuals residing in developed countries. The enhancement of greater access to health care, clean water, and shelter has led to an increase in life expectancy. Individuals are now living much longer than previous generations. However, as the mortality rate declines, the birth rate in many developed nations such as the United States, Japan, and Finland is declining as well. As a result, the dependency ratio for developed countries are rising at a startling rate and the demographic of developed countries are transitioning to a much older median age group. Older adults are projected to be a pivotal force and their needs will require much policy education. The article attempts to add to the small body of literature that analyze the current transportation needs of older adults.

The paper will give an in- depth overview of common themes and factors that interconnect with transportation behaviors of older adults. It attempts to summarize key practices and concerns of older adults who have limited access to transportation. The article aims to describe the underlining issues to providing alternative transportation for service providers in primarily two locations, rural and urban setting. The location of residence has a significant impact on the ability of older adults to meet their transportation needs. The paper will provide an overview of the current operation procedures of agencies. There are a few, practical solutions to provide the ongoing transportation for older adult's transport needs.

The first section of the paper will introduce the factors of the transportation problem. Then the paper will provide an overview of the demographic population change expected and rapidly occurring in the United States. The paper will also review recent tables and graphs providing a snapshot of the personal characteristics of the aging population. Thirdly, the paper will provide an overview of the current practices and methods utilize to study transportation barriers. Lastly, the paper will describe counter solutions and provide final thoughts of the next step researchers should take in meeting the transportation needs of older adults.

The older adult population worldwide is predicted to increase as the average life span in industrialized countries has risen to eighty-two years old. The increase in life span for older adults is a direct response to medical advances and higher standard of living (Pristavec, 2018). In the United States, transportation needs of older adults are gaining traction as a growing problem (Ball & Rebok, 1994). Older adults in urban settings can access transportation, groceries, and medical services at a more efficient rate than their rural counterparts. In prominent cities, such as Los Angles, there are more opportunities to acquire funding to reduce and even waive fees for public transit for older adults. In the state of Georgia, the public transit system is almost non-existent outside of the state capital, Atlanta. Georgia has comparatively underdeveloped transportation system and older adults still heavily rely on personal vehicles to meet their transportation needs. Although older adults have a longer life span than previous generations; access to reliable transportation is a significant problem that needs to be addressed.

There is a small, yet growing body of literature that details the problem older adults encounter with an absence of transportation options (Ball & Rebok, 1994). The lack of transportation mobility leads to older adults experiencing or predispose to mental and physical health problems. Older adults are often advised to keep their driving license till they are medically unfit to drive. Driving mobility is essential for older adults to maintain independence and the ability to be self-efficient. Older adults who either voluntarily or forcibly give up their license often report a diminished sense of self-worth or helplessness derived from their continual need to rely on others (Pristavec, 2018). There is a very negative perception of older adults who cease to drive as “incapable and needy” (Owsley et al., 1998). The image projected upon older adults often leads to a higher rate of mood disorders present in the aging population.

The mood disorders commonly experience by older adults is depression and anxiety. Older adults, even when they can maintain their ability to drive have reported anxiety about driving at certain times of the day or leaving their home in general. Older adults who still drive feel the need to restrict their driving to avoid night trips or peak travel times. The study, *Driving Avoidance by older adults: Is it always self-regulation*, have reported the aging population’s fear of causing or being involved in a car accident. Older adults who

experience physical limits such as night blindness or exhibit slower reflexes are more likely to be involved in an accident. The concern is not unfounded as an older adult has a higher risk of fatality or need of long-term recovery because of a car accident (Ragland et al., 2004). Social isolation is another negative factor experience by older adults. Social isolation is more than feelings of loneliness or lack of social engagement. Social isolation is when older adults have limited communication with the outside world and connection with other community members (Barr, 1991). Social isolation is stated to lead to not only mood disorders but decline in cognitive functions as well. There is an increased risk for older adults who experience social isolation to develop dementia, and Alzheimer. The effects on an older adult's body can be just as damaging with higher risk of developing hypertension or loss of mobility from lack of movement. The physical determinants of losing travel mobility are as great as the mental decline older adults may experience in late stage of life.

Lastly, studies have emphasis older adults negative experience with transportation problems, but few have noted the significant strain on family and health care systems as a result. Older adults who can no longer drive rely on their family members to meet their transport needs. Their adult children will drive them to medical appointments, the grocery store, and even social gatherings. Their adult children have families of their own, work full-time, and often live a substantial distance from their parents. In the 21st century, it is now common for children to migrate further than the cities or towns they grew up in for career and social advancement. The ability to care and meet the needs of their parents often conflict with other social obligations, so adult children will often make the choice to admit their parent to an assisted living facility (Frey,2010). The admission to a nursing home is often pre-maturely made and the room could have been occupied by an older adult who has a higher list of care needs (Freeman et al., 2006). The nursing homes are often short-staff and rooms wait-listed due to the high percentage of older adults needing care. The adult children often struggle to pay for their room and board in a nursing home, especially if their parents lack sufficient funds themselves. Medicare (a taxpayer funded program) will often step in to cover the cost of boarding. The family and health care system are greatly impacted by the lack of transportation and fosters a social burden (Sanders, 2019).

These studies suggest there is some consensus about the damaging effects that the lack of transportation has on older adult's health; however, there is disagreement about how to provide alternative transportation to older adults. The most proposed solutions to resolving the transportation crisis is providing driving education programs, ride-share partnerships, and implementing volunteer driving programs. The most ideal situation is communities, helping older adults to keep their license, but due to the natural aging process this will not be a sustainable option.

DEMOGRAPHIC

The United States older adult population is expected to grow rapidly because of a longer life expectancy and better health functions than previous generations. The older adult population is projected to outnumber the population of children for the first time in U.S. history (Roberts et al., n.d.). In 2060, the population aged 65 and over is projected to be more than 94 million to rise to nearly 24 percent of the total population. However, older adults remain a vulnerable population with a unique, growing set of needs. The increase interest in how to provide access to reliable, safe transportation for older adults. As the older adult population continues to grow, so does the need for policies to address public and private transportation options for older adults.

Baby Boomers are the second largest age cohort in the United States. In 2011, the oldest of the Baby Boomer age cohort turned 65 years old. They are rapidly entering the later stage of life and their needs are changing as a result. A brief overview of the gender, educational attainment, and income level of the baby Boomer group predicts a high level of intervention needed in their late years. Baby boomers have enjoyed more economic benefits than their parents but are much more prevalent to suffering from physical and mental aliments cause by transportation barriers in contemporary society. The spiral fragmentation of suburban and rural communities greatly affects older adults' ability to successfully age on their own.

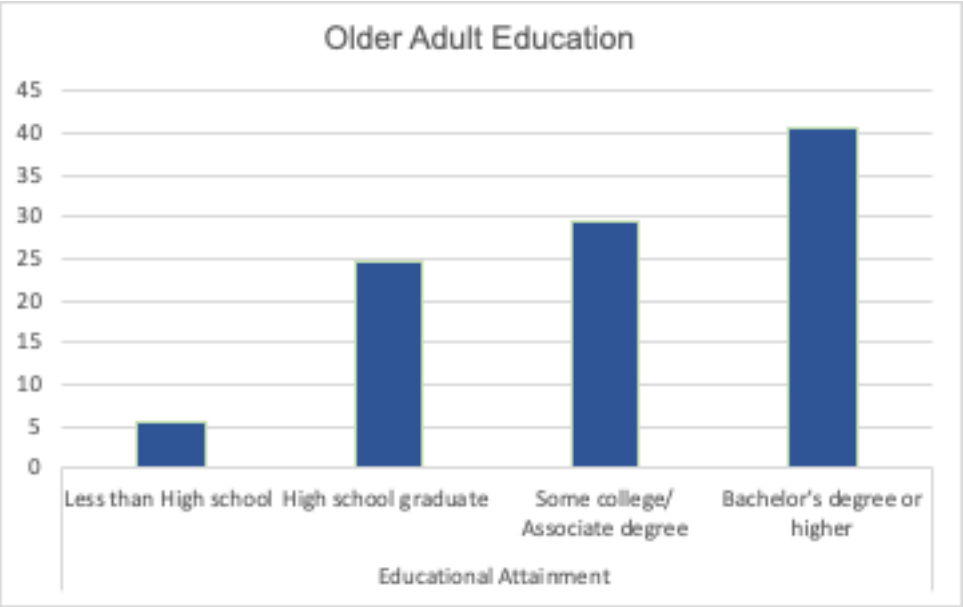
The studies to better address the problem chose different ways to approach the demographic of the aging population. The authors of Alsneir and Hensher divided the older adults into two categories: young older adults (65-75), and old older adults (75+). The studies who interviewed and gather data directly from the aging population made a further distinction between travel patterns in the group. This allowed researchers to better describe the movements of older adults and highlight activities that were vital to their health (Alsnih & Hensher, 2003). Old, older adults traveled primarily for medical appointments and less likely to travel to participate in social gatherings. While young, older adults still travel to meet with friends and attend social functions. Old, older adults reported a higher level of social isolation that on the surface seem intentional on their part. However, through in-depth questionnaires researchers learn most of their friends had died and family were rarely able to visit them.

The studies also noted the gender of the aging population was distinctly more female than male. A woman's life span is determined to be twice the average years of a man. As a result, the graying population's gender is proportionally female. The studies noted that female older adults who could no longer drive heavily relied on their spouse to meet their transportation needs. Once their spouse died or gave up their license, they struggle to find alternative ways to travel. Older adult men were more likely to be able to maintain their license and to keep driving despite their advanced age. However, the studies rarely included responses or feedback from their neighbors/ relatives who would often stand in the gap and help them meet their transportation needs.

Key Demographic Characteristics of Older Adults
Table One

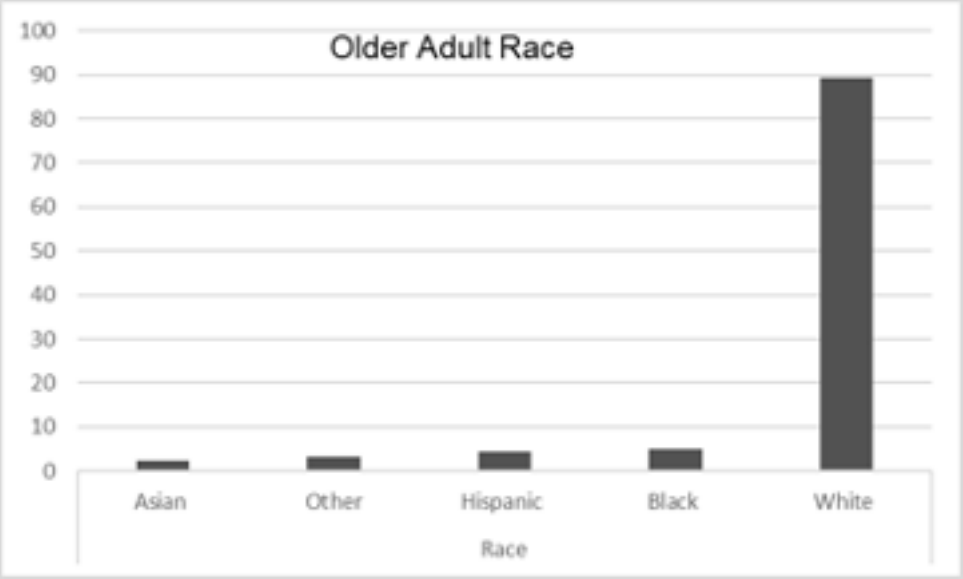
Variables	2017 NHTS (%)	Variables	2017 NHTS
	Use of ride-hailing in past 30 days		
Personal Characteristics	2.0%	**House Hold Characteristics**	
		Smartphone Use	
		Yes	62.46
		No	37.54
Age group	63.07	**Family Income**	
65-74	28.22	<$10,000	3.18
75-84	8.71	$10,000 to<$15,000	5.06
85+			
Gender		$15,000 to<$24,000	10.70
Male	47.25	$25,000 to<$34,000	12.03
Female	52.75	$35,000to<$49,000	14.89
		$50,000 to<$74,000	19.92
		$75,000 to<$99,000	13.33
		$100k to<$125,000	8.89
		$125kto<$150,000	4.05
		$150kto<$200,000	3.83
		>$250,000	4.12

Source:



Graph One

The graph above describes the education attainment of United States population of older adults in 2017. There is a high percentage of older adults who have obtain a bachelor's degree. Higher education attainment is link with lower levels of poverty and the ability to earn more over an individual's working years.



Graph Two

The graph above describes the race makeup of the aging population in the US in 2017 and the population is still predominantly white. Higher health disparities and transportation barriers often leads to higher mortality rates in aging minority groups.

CURRENT PRACTICES

The communities who provide driving education or volunteer programs have a limited range of services and can be costly for the organization to fund. The operating cost would include the purchase and maintenance of vehicles for defensive driving practice. The operator would also have to expend resources to training volunteers, developing routes, and purchasing insurance. Organizations could be able to offset the cost by having a sliding scale or a monthly fee to use their services. Older adults have an express weariness of long routes and riding with strangers. The following factors are why ride-share programs such as Lyft and Uber have not gained traction with adults over the age of sixty (Trigub, 2017). However, if given the option, older adults would use Lyft if they were unable to drive and public transit was not available. Medicare has partnered with ride share program Lyft, to provide rides for non-emergency medical appointments (Trigub, 2017). The agency arranges for the pickup and drop off point, so older adult riders do not have to be concerned with using the app. In rural settings, Lyft and Uber are still widely un-available due to a low projection of potential clientele and Medicare cannot arrange this service in rural areas. The studies suggest the ways states can meet the transport needs of older adults. However, the solutions suggested are mere band-aids to a complex problem.

The studies described the demographic by age, gender, and location. The location was the third important factor defining the transportation needs of the aging population. Whether the older adult resides in a rural or urban setting had a huge impact on their ability to access transportation. Highly effective community-based programs were suggested to be better at resolving lack of transportation for individuals living in less populated areas. Ride- share programs, such as Lyft and Uber are not readily available in rural communities. A volunteer program started by a non-profit organization or neighborhood would be more effective to meet the transportation needs of the older adults who reside in a rural setting. A few studies proposed government funding to provide more public transportation in rural setting, but the problem is sustaining the program long-term (Pristavec, 2018). Older adults who live in rural settings have a higher need to travel greater distances to hospitals, grocery stores, and pharmacies. Simply, the essential business services were only available in the higher populated cities which would often be in the next town over. Older adults tried to stagger their trips so they would be able to meet their needs efficiently. Often older adults decided on what they would have to go without due to time constraints and ride-insecurity. Location was a great interest to researchers as they describe the travel patterns of older adults.

METHOD

The older adult population is a unique population and researchers have noted potential problems in collecting data from them. The studies have noted scammers and fraud attempts to target older adults, which made it particularly challenging for older adults to be willing to answer questionnaires. Researchers would often seek a local community leader or senior service center to help facilitate the participation of older adults. The studies that had a trusted third party to provide an introduction help the researchers to collect personal information about the aging population's travel patterns (Yamamoto & Zhang, J. 2017). As previously mention acquiring responses from neighbors and family members about the support they provide was hard to acquire. If researchers were even able to make contact, most family members decline to answer questionnaires or to be interviewed by researchers (Yamamoto & Zhang 2017). The data if acquire, could help researchers better describe the social burden place upon family and community systems. However, most family members decline in-depth interviews and as a result few studies focus on capturing the transportation problem from the older adult's family's perspective.

The coding process researcher used varied greatly in defining the travel patterns of older adults. In, *The Kindness of Strangers: Exploring Interdependencies and Shared Mobilities of Elderly People in Rural Japan*, describe the current modes of transportation and the problems hindering effective transportation for older adults. The modes of transportation included use of a personal vehicle, bus, walking, and a scooter. The preferred mode of travel for older adults is by far using a car or personal vehicle. In rural areas, essential services are a greater distance away and a car is the most efficient way to travel (Yamamoto & Zhang 2017). When older adults are making a grocery store trip, storing their purchases in a car made the trip simple. However, when riding a bus, the amount of food older adults can purchase and safely carry home is limited. The same grocery trip becomes even more difficult when older adults must walk home if there is no bus route near their home. Older adults who can still walk report having trouble walking on uneven surfaces as there is a lack of sidewalks for pedestrians in rural settings.

Older adults often have a fear of falling and this can cause reluctance for older adults to use this transportation mode unless necessary. Secondly, older adults favor using a bus, but transit can be unavailable or even hard for older adults to navigate (Yamamoto & Zhang 2017). The long routes to get to their stop and the need to change bus lines make the experience taxing for older adults. A few studies suggest introducing guides to help older adults understand how to pick a route, ride a bus, and help navigate if they get lost (Rahman et al., 2020). A guide would be especially helpful to support older adults who have a physical disability caused by side effects of prescribed medications or health treatments. A large percentage of older adults are undergoing medical treatments or have been described medication to help with ailments. Older adults can in some instances substitute transit for scooters, but this mode of transportation is best for small distances. Sidewalks are again uncommon in rural settings, so older adults would have to be vigilant of cars.

The authors, Yamamoto, F and Zhang, J, describe the problems affected the modes of transportation using a provisional code developed by Church et al. The coding list includes physical, geographical, economic, time-related, fear or safety, information-related, and social networks, and cultural factors. Although the study was executed in Japan, the factors that affect older adults in rural America are not vastly different. The provisional coding could be replicated in studies in rural Georgia and would give researchers ample information on defining the problems of transportation for older adults. The provisional coding can be assigned a numerical value, allowing researchers to design a questionnaire. The responses provided by the older adult participants can be matched to the assigned value system and the data analysis of the exact impact a factor has on the random sample aging population. For instance, *In the Kindness of Strangers*, researchers depict the Why Older Adults travel and How by creating a table to showcase the data of the purpose and mode of travel. The table was able to be created because the researchers had a decisive understanding of the preliminary factors affecting transportation of older adults.

MENTAL AND PHYSICAL

A great cause of concern for practitioner and policy makers is the mental health consequences of prolonged lack of access to transportation. The primary mode for older adults to travel per a personal vehicle. When an older adult has suspended or cease driving because of natural aging process; slower reflexes, vision impairment, or lessen mental cognition (Social isolation, loneliness in older people pose health risks.) Their options for alternative transport are greatly reduced and many older adults rely on others to assist in meeting their transportation needs. The loss of independence can greatly affect the self-esteem of older adults. A low level of self-esteem has been linked with an increased risk of depression and feelings of hopelessness. The retirement years are supposed to be the "golden years" where older adults enjoy their time after working for many years. Instead, many older adults due to loss of independence have a variety of signs of high stress and anxiety. Stress and anxiety can accelerate the aging process of older adults, leading to higher risk of being diagnosis with dementia or other cognitive disease. The declining of mental capacities can accelerate the families need to intervene and deepen further loss of independence of older adults. Most older adults prefer to age in place or remain where they have raised their kids or pursued their careers. A deterioration of mental capacities further threatens their ability to care for themselves and live independently creating more feelings of hopelessness. A cycle that can continue to create more mood disorders and increase the medical professional assistance needed in their lives. Often, mood disorders such as depression, anxiety, and even suicide ideation are underreported in the general population. The stigma of mental health is very prevalent in society and in the older adult population mental health diagnosis is even more uncommon. The life events of baby boomers, that included war and scarcity, have made it hard for many baby boomers to share about their experiences, let alone for them to seek mental health treatment. Older adults will often endure feeling mentally unwell at the cost of their overall wellbeing.

Another factor affecting the mental health of older adults who lack transportation is social isolation and loss of social networks. Humans are social creatures and isolation has proven to be detrimental to the mind maintaining and developing continual functions. Successful aging has been directly linked to older adults creating or maintaining some social participation. For the general population, social networks are developed through family, school, and work institutions. When older adults retire, they reduce their ability to have social capital as the opportunity to socialize with the general population is greatly reduced. The ability to attend religious functions, volunteer, or even participate in a hobby increases the ability for older adults to maintain cognitive functions. Social participation allows older adults to find purpose and to still interact with others who are not their chronological age group. Higher social participation among older adults is also tied to higher feelings of life-satisfaction and higher reported self- esteem. Once again when older adults report low self-esteem they have increased chances of developing mood disorders. When older adults exhibit high levels of life satisfaction, they are less likely to develop depression or anxiety. Older adults who can regularly see their kids or grandkids also report higher life satisfaction. The current way families are organized, older adults do not have the opportunity to see their adult children or socialize with their grandkids very often. In the United States, adult children will often live thousands of miles from their parents. The adult children often migrated to pursue education or career goals with the intention of coming back later. However, very few of older adult children return to the same region. Family members are the first source of social capital for older adults and a second would be their neighbors. When older adults, especially in rural communities do have the ability to transport themselves, family visits are a top social priority. When the family is less involved the social isolation can cause extreme feelings of insecurity and a simple way for older adults to remain active and engage in their golden years is for them to have access to transportation. Transportation allows older adults to age with dignity and encourages continual high self-esteem, which in return lowers chances of mental health ailments (Takemoto et al., 2015).

The physical ailments endured by older adults are often compounded by the loss of transportation mobility. Often, older adults experience a decline in strength, vision, and even bone density (Walker, 1999). The effects of aging can be limited with an active and healthy diet. However, lack of transportation limits the ability for older adults to leave their houses or apartments. Older adults without the capability to leave their homes carry out very few physical activities. The ability to move our bodies and remain active is essential for successful aging. The physical decline can lead to higher mortality rates in older adults and shorten their life expectancy. High blood pressure, diabetes, and high cholesterol are just a few of the diseases that increase in prominence with a sedentary lifestyle. Practitioners have compared being inactive as the equivalent of smoking cigarettes. The physical decline can also manifest because of poor dietary options or fail to keep up with long-term chronic illness treatment. When older adults must rely on others to drive them, they often stagger trips to avoid being a “burden” to friends and neighbors. The staggering of trips leads to older adults often neglecting or delaying

medical treatment for conditions such as diabetes or cancer screenings. The treatments and screenings are vital to continuing ongoing success of their health care plans. When older adults neglect their treatment plans or medical visits, they often risk accelerating physical impairments(Takemoto, M., Carlson,)The risk of not taking medications and passing on screenings includes a progression of an illness, hospitalization, and increase mortality rate. Older adults are delaying essential services in a bid to retain some dignity and a lack of transportation options.

Their physical wellbeing also relies on having access to regular meals which require routine trips to the store. Many older adults cannot afford to buy in bulk because of their fixed income; especially when social security is their only source of income. Often older adults will instead choose to forgo food when having to choose between medication or paying other living expenses such as rent/ mortgage. Older adults who live in rural communities will have even fewer local options to be able to purchase food from. The distance and commute time to a store greatly determines when and how many times a month they will go to the store. When an older adult already has underlining health issues, skipping meals or irregular eating patterns does not increase their ability to cope well with their chronic illness.

COUNTER-SOLUTIONS

A surprisingly few studies describe the financial situation older adults face that affects their ability to afford transit. A significant number of older adults in rural settings primary income are from the Social Security Administration and there is a slight increase in poverty levels by age. For example, the increase in poverty levels is 7.9 percent for those aged 65 to 74, and 9.8 percent for those aged 75 to 84 (Schwebel et al.,2007). The provisional coding used in, *The Kindness of Strangers*, does describe the economic factors as affecting travel frequency or limit access to essential services. The ability to have access to affordable transportation option can mean the difference between having medical treatment, continued supplies of food, and maintaining social connections.

Older adults who are on a limited budget can severely impact their ability to maintain a positive quality of life where they can get access to key essential services. A few studies proposed offering free or discounted vouchers to ride buses or taxi services. However, ride- share platforms are limited option for older adults residing in rural communities (Trigub, 2017). A tax credit or subsidy provided to older adults in rural communities could help with resolving income problem with acquiring transportation. The tax credit could refund them at the end of the year for transportation related expenses. The transportation of older adults will continue to be a focus point in aging and public policy as the demand for alternative services grow. Future studies should focus on surveying current community-based transportation programs and survey individual's response to limited transportation options.

CONCLUSION

Older adults have a desire to be included in society during the later stages of their life. They desire to be able to socially participate in many of the functions we take for granted. The ability to drive to a social gathering, the grocery store, or the doctor becomes very hard to navigate, especially when they cease driving. When an individual can no longer transport themselves there are few, less costly alternatives to a personal vehicle. Ride – share programs can be costly for individuals to pursue and few are available in rural settings. Older adults do not want to depend on family or friends for their transportation needs but there are few available alternatives. Often, older adults will sacrifice their desires to prioritize essential transportation needs, grocery store and doctor visits. Their ability to socialize with the rest of the community is greatly compromised and the start of social isolation begins. The affects on their mental and physical health is astounding; higher rate of mortality, decline in cognitive function, and higher risk of developing depression. The higher risk of developing adverse diseases leads to negative feelings in life satisfaction. As older adults continue to age, the ability for providers to provide alternative solutions to the transportation problem is imperative. The quality of life of older adults will continue to decline, especially for those who have a low-income and disabilities. The paper aim to give insight to the changing demographics in the United States and how transportation needs of older adults is an important social problem. We have discussed in the paper how older adults' quality of life is greatly affected and even shorten due to lack of transportation mobility. The importance of researchers to continue to explore the issue of aging and transport is imperative for informative public policy. The research could very well assist families and health care providers in the care of older adults. The ability for older adults to age with dignity is a small motivation when the social cost of older individuals enduring social isolation is accounted for. It is within the best interest of society to assist older adults with their transportation needs, so they can maintain healthy aging for as long as possible. The return will be lower assisted living cost, lower cost expended Medicare, and higher-life satisfaction for our older adult population.

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Educación en Frente y Inmigración en la Mente: The Effect of Immigration on the Mental Health and Academic Experiences of Latinx College Students

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ABSTRACT

As the Latinx population is growing and more students who identify as Latinx are entering higher education institutions, literature has not clearly discussed how immigration can impact this vulnerable population academically and mentally. Thus, the purpose of this study is to examine the effect of immigration on the acculturative stress, anxiety, and academic experiences of Latinx college students. This research used a mixed methods approach; participants were surveyed and interviewed to measure these levels and to speak specifically about how immigration has impacted their K-12 and postsecondary educational experiences. Results showed there were no significant differences between first-generation and second-generation immigrants' levels on acculturative stress and anxiety. Overall acculturative stress was positively correlated with overall familismo and with familial honor, a subscale of familismo. Additionally, Latinx participants discussed similar themes across interviews about ESOL classes, differences between home culture and school culture, parental involvement and academic expectations, and lacking resources when preparing for college on their own. As more immigrants and children of immigrants are enrolling in higher education, the findings of this study have important implications for understanding the influence of immigration on acculturative stress, anxiety, and academic experiences. This study will allow faculty and staff to better understand the barriers Latinx college students face in education.

Keywords: immigrants, acculturative stress, anxiety, familismo, academic experiences, Latinx college students, mixed methods

INTRODUCTION

In the U.S., the Latinx population is growing exponentially, especially the younger adult population. In the 2010 census, the Hispanic/Latino population was at 16 percent and it showed to have increased from 2000 by 10 percent (Albert, Ennis, & Rio-Vargas, 2011). With the growth of this population, there has also been an increase in Latinx K-12 students and immigrants enrolled at higher education institutions across the nation. The University of North Georgia, the site for this study, has 5 campuses with the two most populated campuses being in Dahlonega and Gainesville. Gainesville has had an influx of Latinx residents in the past 20 years, which has resulted in the increased enrollment of Latinx students at the University of North Georgia. During Fall 2020, 14.6% of the population at the University of North Georgia is Hispanic/Latino (University of North Georgia Quick Facts, 2020). In Fall of 2016, the University of North Georgia had 11.4% of the population who identified as Hispanic/Latino (USG Semester Enrollment Report, 2016). With this population increasing steadily, the institution is on its way to becoming a Hispanic-Serving Institution, a higher education institution with 25% or more total undergraduate Hispanic full-time student enrollment (U.S. Department of Education).

Immigrant Generations & Mental Health

The Latinx population is the largest minority group in the United States and has been quickly increasing in number over the past few decades (Albert, Ennis, & Rio-Vargas, 2011). However, there is not clear research on the mental health of the Latinx population, specifically on college students. For the Latinx population in their late teens and early twenties, they are now in the workforce or continuing their education. These two groups would be named the first- and second-generation immigrants. First-generation immigrants are those who were not born in the country they currently reside in and second-generation immigrants are those who were born in the United States, but have parents or guardians who immigrated here (L. Rogers-Sirin et al., 2014). When comparing these two groups, there has been a theory called the "immigrant paradox," which suggests many differences between these two groups regarding their overall health. For example, the immigrant paradox states it is expected for first-generation immigrants to have poorer overall health than those born in the United States (Alegria et al., 2017). However, it has been found to be the opposite, which causes confusion when it comes to this theory (Alegria et al., 2017). These two groups are having to take on experiences their parents may not have faced growing up in their home countries. It is important to take the backgrounds of Latinx college students into consideration when talking about mental health, an important facet of their overall health.

Impact of Immigration and Familismo

Immigration has also affected the physical and mental well-being of Latinx children due to the fact that their parents have their own barriers making them unable to provide health resources for them (Flores et al., 1998). Overall, Hispanic children have less access to healthcare than children of other races and ethnicities (Perez-Escamilla et al., 2010). The parents of these Latinx children face language barriers, which can lead to misdiagnosis and inappropriate treatment for the children. Another barrier is non-citizenship status amongst the parents and/or the children. This causes the parents to be less likely to reach out for help due to fear of deportation or because they are ineligible for helping programs (Perez-Escamilla et al., 2010). The job status of the parents may also affect the overall healthcare resources their children might have, such as being farm worker. Parents who are farm workers are at risk for overall health problems and are less likely to be insured (Perez-Escamilla et al., 2010). However, schools are able to help with providing resources to support the mental health of students. School-based mental health professionals, such as school psychologists and counselors, can help discuss problems going on in their life. There are also programs that have been created to help Latinx students stay in touch with their culture which also helps support them mentally as they make the transition from their home countries to their new countries (Gonzalez-Ramos & Sanchez-Nester, 2001). While some of the Latinx population may have trouble obtaining healthcare resources, they are able to rely on their family members for support.

For the Latinx community, there are many cultural values that relate to family since their family members act as a major support system. This is why it is important to understand the influence of immigration on this cultural value of familismo (Ayon et al., 2010). Familismo is the bond of one's family; it has been found to have negative associations with mental health symptoms, meaning that the stronger the family bond the less likely one is to develop mental health problems (Corona et al., 2016). This cultural value plays a central role for Latinx students as it impacts many of aspects of their lives, such as career decisions and educational opportunities. The social support and ethnic identity protect the Latinx youth from internal mental health symptoms (Rogers-Sirin et al., 2014). It also acts as a buffer between stressors and mental health of Latinx college students (Crockett et al., 2007). This generation of Latinx students have seen changes in immigration policies which may have affected their families. A more recent problem to arise in the past 20 years is the separation of family members due to changes in immigration laws. There have been more instances of parents being deported and taken away from their children which adds stress onto the family, as a whole. It has also been shown that greater social support is associated with lower depression and lessens the influence of stressors on health (Alegria et al., 2017). Many immigrants are separated from their family whenever they leave their home country, especially men, which means they lose their main source of support. Immigrant men also have higher levels of extrafamilial stress than documented immigrants and women, which contradicts how they are more likely to be separated from their nuclear family (Arbona et al., 2010). It is also important for the Latinx first-generation college students gain most of their motivation from their support networks (Vega, 2016).

Acculturative Stress

One of the many challenges Latinx immigrants are having to face is acculturative stress, which can impact their educational and mental health outcomes. Acculturative stress is seen when immigrants face challenges while settling into their host cultures while also keeping their home culture (Rogers-Sirin et al., 2013). Over time, acculturative stress can affect the mental health of immigrants. In Rogers-Sirin et al. (2013), the researchers collected data from high schools to examine the relationship between acculturation and mental health outcomes for first and second-generation college students. It was found that first-generation youth reported greater acculturative stress than second-generation youth going against the "immigrant paradox," which suggests that second-generation immigrants report higher levels of acculturative stress than first-generation immigrants do. An increase in acculturative stress over time can cause an increase in internal mental health symptoms. First-generation immigrants also experience higher levels of withdrawn/depressed symptoms in comparison to second-generation immigrants. In regards to first- and second-generation immigrants, these greater levels of acculturative stress can have an impact on their educational and health outcomes. In some cases, the educational environment can cause acculturative stress for students. Rogers-Sirin et al. (2014), talks about how differences between family cultures and the school can be a source of acculturative stress in bicultural students since these two contexts affect a child's development. For example, a difference in family culture and the school culture can be the language. If the child feels uncomfortable in the school due to the difference in language, they may be silent and have trouble socializing with their peers (Gonzalez-Ramos & Sanchez-Nester, 2001).

Within the first-generation immigrant group, there are two groups within this community of the Latinx population due to their legal statuses -- documented and undocumented immigrants. Undocumented immigrants tend to report higher levels of fear of deportation, especially men rather than women and documented immigrants (Arbona et al., 2010). These fears of deportation can cause more stress and anxiety in their lives. When it comes to postsecondary education, undocumented immigrants also face issues with the opportunity to enroll in colleges and universities. Since many states require for undocumented immigrants to pay out-of-state tuition, many of these students are unable to pay the thousands of dollars out of pocket and are unable to apply for loans as well.

Educational Challenges in K-16

The first-generation immigrants who are coming here as children face many problems that go unrecognized by their families, teachers, and friends. These children may be going through a culture shock that can cause them to struggle academically (Gonzalez-Ramos & Sanchez-Nester, 2001). Immigrant children who come here at an older age and attend school tend to have more difficulties with their academic work. If students were helped to embrace both their home culture and their new culture, this would provide a way for schools

to respond to their mental health needs (Gonzalez-Ramos & Sanchez-Nester, 2001). Another factor that can affect the education of immigrant children are their teachers' perceptions and expectations of them. These perceptions can include being silent and detached in the classroom, which may cause the teacher to have low expectations for the student. (Gonzalez-Ramos & Sanchez-Nester, 2001). The differences in cultural values between immigrant parents and teachers in the United States can cause lower expectations towards these children immigrants, which can lead to negative educational outcomes (L. Rogers-Sirin et al., 2014).

For many Latinx college students, immigration has either affected them personally or it has affected their families. Immigration can affect families as a whole when they are of mixed immigration statuses. This can impact their postsecondary experiences when they attempt to apply for their FAFSA applications and aren't sure what to insert for their parents' legal information. It is important to understand the impact the K-12 school systems have on Latinx students and their motivation to pursue postsecondary education. Students who were enrolled in more challenging courses throughout middle and high school indicated dual enrollment and pre-AP classes as a factor of why they pursued postsecondary education (Vega, 2016). Teachers have a major role in motivating their students towards their academic advancements. For example, if the faculty members of the high schools believe the student has the ability to obtain a higher degree then the student will believe they should not settle for less (Vega, 2016). Most Latinx students are first-generation college students and may lack the resources helping them towards getting to postsecondary education and completing the degree (Vega, 2016). The support networks of students are always a contributing factor to their educational success. The value of education in the family culture dictates whether or not the Latinx student decides to pursue postsecondary education. While Latinx students have pressure from their parents to succeed in school, their parents may have less experience in navigating the U.S. school system. Schools may sometimes perceive Latinx families to be uninterested in their children's educations, due to their lack of attendance. However, Latinx parents usually have high educational standards for their children (Ceballo, 2004). Relevant research suggests low parental school-based involvement may be due to inflexible jobs or cultural differences (Alexander et al., 2017; Trevino, 2004). First-generation college students also have the responsibility to be the first to complete college in their family, which puts more stress on them (Vega, 2016). Stress placed on the student to accomplish this achievement can either motivate the student to obtain their college degree, but it can also be another limitation since the student doesn't have someone to turn to. However, it is important to recognize how important family support is for these Latinx first-generation college students since they gain most of their motivation from their support networks (Vega, 2016).

Specific Aim & Hypotheses

Previous research has focused more on adolescent Latinx students (Gonzalez-Ramos & Sanchez-Nester, 2001; Rogers-Sirin et al., 2014; Sirin et al., 2013;). In this study, I investigated Latinx first- and second-generation immigrant students in college and how their experiences with immigration may have impacted their mental health and their academic experiences. While this study didn't specifically ask about the status of students, it should be kept in mind that this group includes Latinx students who are undocumented, DACA dreamers, permanent residents, and U.S. born citizens. Within this group, each one of these students currently or in the past has faced their own problems with immigration. In the present study, I have assessed self-reported levels of acculturative stress, anxiety, familismo, and I have also assessed the academic experiences of Latinx students through semi-structured interviews.

This study hypothesized that first-generation immigrant Latinx college students and second-generation immigrant Latinx college students would report similar levels of acculturative stress and anxiety since the immigrant paradox has been proved right and wrong. Additionally, the study hypothesized that overall acculturative stress and anxiety would be negatively correlated with overall familismo. Lastly, it was hypothesized that immigration would have a negative impact on the academic experiences of first generation and second-generation immigrant Latinx college students with common themes, such as parents being less involved in K-12, school culture differing from home culture, having fewer resources when applying to college, and less higher education options.

METHODS

Participants

All participants recruited for this study attended a public university located in the southeastern United States. A total of 47 participants completed the survey portion of the study. Of these 47 participants, 12 students signed up to participate in a follow-up interview to discuss their academic experiences. In this survey, there were 36 females, 10 males, and 1 nonbinary participant. The survey had 95.7% of the participants identify as Latinx while 4.3% identified as biracial. The participants who identified as biracial identified as Latinx and African-American. Participants varied in countries of origin; Mexico was the most reported country of origin for the participants (63.8%). The majority of participants were second-generation immigrants (74.5%) and 25.5% of the participants were first-generation immigrants. The majority of participants for this study were first-generation college students (85.1%). The mean age of participants was 21.19 years old and the median age of participants was 20 years old. The standard deviation of age for the participants was 5.03.

Procedure

These students were initially recruited by reaching out to the leaders of Latinx-based organizations within the university and through the Psychology department's research database. Recruitment took place through emailing, social media postings, and club/organization meetings. Participants completed the survey online on their own time. After completion of the survey, the participants would then be asked if they would like to participate in a follow-up interview specifically about their academic experiences.

The participants for the interview portion of the study were recruited from the group of participants who participated in the survey portion. Emails were sent out to survey participants who agreed to be in a follow-up interview. The email contained a link to a website with 12 time slots for students to sign up for individual interviews. Students were asked to electronically sign the consent form before the interview was conducted. The interviews took approximately 30 minutes each. Each interview participant received a $10 gift card for their participation.

Measures

The online survey included demographic questions and multiple scales to measure acculturative stress, general anxiety, and familismo. The Social, Attitudinal, Familial, and Environmental, Acculturative Stress Scale were used to measure acculturative stress levels of the participants (Mena et al., 1987). This scale measured amounts of stress in 4 different aspects. These 4 aspects were social, attitudinal, familial, and environmental. This measure looked at the loyalty to the American culture, the participant's locus of control, and one's self-esteem. This scale had 24 items and has the participant rate each question on a 5- point Likert scale. The scale ranges from 1 being "not at all" to 5 being "extremely stressful." The measurement of acculturative stress was calculated by using the total score from all the questions.

In order to measure anxiety levels of the participants, participants were given the Beck Anxiety Inventory (Beck et al., 1993). This is a 21-item survey used to measure anxiety symptoms. Participants responded to various questions using a 4-point Likert scale ranging from 1 to 4. Total anxiety was calculated by combining the score from all the items.

Participants also completed an Attitudinal Familismo scale (Lugo Steidel & Contreras, 2003). This is an 18-item scale asking questions about familial support and interconnectedness. The participants responded to each question on a 9-point Likert scale. This scale is made up of 4 subscales: familial support, familial interconnectedness, familial honor, and subjugation of self for family. With these subscales, the score was calculated by combining the scores from the questions that followed each theme. For the overall score of familismo, the average of all the items was calculated.

The interviews were conducted by following a semi-structured interview guide (Appendix A). The semi-structured interview was created using the research questions that were guided by the hypotheses. The hypotheses allowed for the formation of questions in determining which factors may cause a difference in academic experiences of the students. After this step, specific aspects of these factors were unpacked to identify specific problems that could have arose in the academic experiences of Latinx students (Schensul & LeCompte, 2013). This guide was made up of questions regarding the participant's background, K-12 experience, college experience, difficulties with immigration and the lack of immigration resources in the community (Appendix A).

Once the interviews were conducted with all twelve participants, the interviews were transcribed through UNG MediaSpace. Interview transcriptions were then edited and labeled with initials of participants. Data from these transcriptions were then coded into similar themes across all interviews using In-Vivo Coding. In-Vivo coding was chosen to analyze the qualitative data in this study, so the voices of participants were recognized and prioritized (Saldaña, 2015).

RESULTS

Quantitative Results

Correlations between the dependent variables (i.e., acculturative stress, anxiety, and familismo) were conducted. The findings were not supportive of the hypothesis. Overall acculturative stress was positively correlated to overall familismo, $r(47) = .29$, $p = .046$. This indicates that participants with higher levels of acculturative stress would also have higher levels of familismo (Table 1). Since the Attitudinal Familismo scale had four subscales, correlations between the dependent variables (i.e., acculturative stress and anxiety) and the four subscales of familismo were conducted. Acculturative stress was positively correlated to the subscale of familial honor, $r(47) = .29$, $p = 0.43$, which indicates that participants who scored higher on familial honor were more likely to report higher levels of acculturative stress (Table 2). The other subscales of familismo were not statistically significant in the correlations conducted.

Next, an independent samples t-test was conducted to compare the general anxiety and acculturative stress levels for first-generation immigrants and second-generation immigrants. There was no significant difference in reported acculturative stress levels between first-generation immigrants ($M = 58.67$, $SD = 20.51$) and second-generation immigrants ($M = 49.91$, $SD = 13.92$), $t(47) = 1.65$, $p = .105$. These results suggest that difference in immigrant generation does not have an effect on overall level of acculturative stress. There was no significant difference in the reported general anxiety levels of first-generation immigrants ($M = 36.08$, $SD = 11.62$) and second-generation immigrants ($M = 34.54$, $SD = 11.17$); $t(47) = .408$, $p = .685$. These results suggest that difference in immigration generation does not have an effect on levels of general anxiety.

Qualitative Results

The 12 Latinx college student participants interviewed for this research study had similar academic experiences when dealing with immigration directly and indirectly. The similar themes found across the participant interviews were ESOL classes, differences in home culture vs school culture, parental involvement and academic expectations, and lacking resources when applying and preparing for college on their own.

Almost all of the participants interviewed had some experience with ESOL classes, whether it was less than a year or for multiple years during their K-12 education. While the majority of participants had an experience with ESOL classes, each experience was different. Some participants felt ESOL classes were a good experience and helped them in their academics. When being asked about their experience in ESOL classes, one student (P1) noted: It's certainly helped. It helped a lot. I know that if I didn't have that program, I would have been more lost." Others felt they grew out of the ESOL classes before being taken out of the classes. One participant discusses her experience with ESOL classes:

> [P2] ...I guess I was in ESOL up until ninth grade of high-school all the way from elementary. I felt like I was excluded of many things. Like from my class in elementary, we would do like activities where you would be like in groups. But then they had to like, go pick me up because I was in ESOL, and I was like but I want to go be with them though because we're doing something fun over there. But no, I had to like get out of the classroom, go to the to the classroom and then learn English. And but I felt like I was pretty good at English by fifth grade... I felt I was stuck there. Well, luckily, there was one teacher she was like, "I don't know why you're in ESOL. You can already be with the other kids over there." Cause literally, the kids that would go with me like I had with me, they were like people that recently came from Mexico or like from out the country. And like they would not know any English.

This student (P2) later explained how this feeling of being stuck in ESOL was because she didn't have anyone to turn to and ask questions about the situation: "I didn't know what to do about it. Honestly, I just didn't know." This situation highlights how ESOL can be beneficial for some students, while also having a negative impact on other students. Without this teacher intervening and removing the student from ESOL, she would have remained in those classes. This shows the importance of having a mentor or advocate within the school system to help these students.

Since the majority of the interview participants shared a similar first language, many also discussed the shift in culture whenever entering their school systems. Upon entering school, some students felt uncomfortable in their school environment since they were still learning English. One student (P3) recalled their experience when entering school: "I like I was really quiet because I couldn't really speak English because I didn't know how to speak it... I you know, I wouldn't be understood. So I was like, what's the point in speaking Spanish?" Another student (P4) discusses a similar experience with the clashing of school culture and home culture due to language: "At the beginning. And in elementary school when I first started school, like I did feel a little bit uncomfortable and nervous and scared and, you know, because I knew that I wasn't saying it right or that my pronunciation was off. So yeah I did feel like a little bit, I guess... like I felt like I couldn't fit in because I couldn't understand them and they couldn't understand me." When participants reflected back on these moments in school, it was noticeable how they felt out of place. These two situations call attention to the bilingual speakers entering school systems and their struggle to make connections with those around them.

A majority of the interview participants shared a common connection when it came to their parents. They were one of the first of their families to pursue college and sometimes the first to graduate with high school diploma. While many of these students were the first to pursue higher education, parents still held high expectations and supported their decision in getting their undergraduate degree. One participant (P5) discusses her mother's academic expectations for her: "...Like college has always been her number one priority for me. And like, I know I know till this day she probably like expected more from me, like when it comes like at academic wise... She knows I like I do my best and she just wants me to keep going forward and get a degree or a career in something." This relates to the association between familial honor and acculturative stress since this student focuses doing her best in school for her mother. This example best explains one of the reasons why acculturative stress was positively correlated with the familismo subscale, familial honor. Another student discussed how her parents were involved in her academics when they saw she was struggling in school:

> [P6] "But after my freshman year there on, they saw that I wasn't doing too well. So they put me in private school. Just help me out with like my grades and later on, college decisions... But after I got to private school, my parents were a little more involved in my schooling. So they were always asking questions of like, hey, have you done this for a scholarship or turn this in? Like it was a little more hopeful, but I still had to figure out a lot of things to tell them what it meant."

This participant showed how parents were still involved if possible. However, as a first-generation college student, this participant still had to navigate the pursuit of higher education on her own. Overall, parents were not involved in school activities unless it was absolutely necessary. Students explained how this was due to a lack of resources for their parents, such as bilingual advocates. Other students discussed how if it wasn't a language barrier keeping their parents from being involved, it was their work schedule.

Of the twelve students interviewed, over half were first-generation college students. This meant they had to navigate higher education on their own without help from their parents. Students discussed their common struggles of not understanding how to complete forms for college on their own. One participant discusses his transition into college and how an organization from UNG was able to help him:

> [P7] Yeah. Basically on my own because because even though to be honest, we had a financial advisor, you had a financial advising coach, and everything. Like it was based on my own, everything was on my own. You know like everything, all the information I provided was just, I mean, granted, I did have help. I did have help that the extra boost of help in case I needed it was because I qualified for the college assistance migrant program...CAMP. I qualified for it unknowingly and I just went for it. They get back they got back to me. They called me and texted me, say, hey, just want to let you know that you qualify for the scholarship. And they, they have a lot of help like for first, first-time generation, first generation college students. They give you a lot of help, you know, pros and tips. That was really good.

Another participant shares a similar experience of preparing for college on her own and her frustration during the process:

> [P8] So I'm the first one in my family. You can say that it's going to college out of everyone. So it's more like learning things and figuring it out all by yourself. Seeing what a GPA means and why being in high school is so important before you enter college or why is FAFSA important, why-what are student loans? It's all of that. It's all learning that in the first year of college. And you're a bit scared and traumatized because you're like what the heck, like no one no one ever told me this. No one in high school ever told me that I had to do this... So you feel lost. But as time goes by, you get used to it. For example, my cousins now are now graduating from high school and they're coming towards me and they're like, what, how do I apply to college? How do I do a FAFSA? And so like now, I can help them out. But it was it was stressful. You don't get that guide. At least in my high school, no one ever told me what to do.

These two participants highlight the difficulties Latinx students have when applying to college as first-generation college students. They're the first to take on the challenge of pursuing their bachelor's degree. With this experience, they know they'll be able to share this information with those who come behind them.

These twelve participants had many similarities across interviews, but there were also major differences depending on their indirect or direct experiences with immigration. Overall, immigration, specifically acculturative stress, may have negatively impacted academic experiences of Latinx students through the differences in home culture versus school culture in K-12; however, all students reported their higher education institution being supportive and accepting of their culture. There was no major impact of general anxiety on the academic experiences of the interview participants.

DISCUSSION

Future Research

The goal of the current study was to investigate the effect of immigration on the mental health and academic experiences of Latinx college students. Future research should expand on the findings of the qualitative portion of this study.

First, 7 out of the 12 interview participants explained how religious institutions play a role in the community when providing help to those dealing with immigration. There was no specific domination discussed amongst the participants, they solely focused on churches in their community. While this study reviewed the value of familismo in mental health and academics, it would be beneficial to investigate the role of religious institutions in future studies. Religious ties are a prominent value in Latinx culture, similar to familismo. Also, religion has been seen to be an important coping mechanism for Latinx immigrants when handling acculturative stress (Sanchez et al., 2012). Understanding how religion can be a coping mechanism for Latinx immigrants has important implications for counseling services. Overall, participants didn't recognize many resources other than those from religious institutions. Little is known about immigration resources in the communities of the participants, which includes the University of North Georgia community. Exploring this specific topic would be helpful for families of college students who are undergoing difficulties from immigration.

Additionally, one could also investigate the ESOL classes and its effect on academic experiences. A majority of the participants had experienced ESOL during their time in K-12, while some of the participants felt they weren't challenged in ESOL classes or felt they were already proficient in English. By investigating ESOL placement specifically, this could help increase Latinx students' academic achievement levels in K-12.

Furthermore, the current study could examine the different levels of stress between groups of students enrolled in technical colleges, associate's degree programs, bachelor's degree programs, and those who are in the work-

force. The comparisons between these different groups would show the impact of workplace or academics on the mental health of young adults. This would also show how immigration has impacted their overall lives, specifically in their decisions in life after leaving high school.

Finally, UNG involvement in recruiting Latinx students through organizations seems to be grabbing the attention of students. Many students discussed how Latinx-based organization specific to the University of North Georgia helped in the process of applying to college, such as College Assistance Migrant Program and Realizing Inspiring Successful Educators. The research of these Latinx-based organizations and their recruitment initiatives would be applicable to other schools in Georgia. Other institutions could expand the study by including all immigrants of all ethnicities, rather than just focusing on the Latinx population. Overall, this would help increase the diversity of higher education institutions in Georgia.

Implications

The results of this study showed no significant differences in acculturative stress and anxiety. These findings are inconsistent with the immigrant paradox and the results in Rogers-Sirin et al., (2014). With this research, it is difficult to understand the necessary resources for each group. However, higher institutions should reflect on this concept when focusing on the Latinx population. The results of this study also showed themes for Latinx college students experiencing high expectations from parents with low parental involvement. Students reported that parental school involvement was low, unless it was necessary. Students said parental involvement was due to language barriers or their inflexible job schedules. These results are consistent with the findings of Alexander et al. (2017), in which the researchers found low parental involvement in school was not due to a lack of interest, but rather issues surrounding socioeconomic status. With this finding, it is important for faculty and staff in all educational settings to examine the needs of Latinx parents and give their more resources to be involved in their children's educations.

Limitations

The current study had some limitations. First, the study had a small sample size, which caused an unequal number of participants in the comparison groups. This also made it more difficult to have meaningful findings. It is possible the sample size was impacted due to data collection occurring during the COVID-19 pandemic. Another possible limitation was the survey not being accessible to those who primarily spoke Spanish, since I was focused on the Latinx population. If there had been a Spanish translated version of the survey, it's possible that there would have been more participants. Next, this topic asked about some very heavy topics in the Latinx community, which may have caused for students to sway away from participating. Thus, future research would benefit from building rapport in person to help students feel more comfortable when participating in this type of research.

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TABLES

Table 1

Pearson Correlations with Average Familismo, Total Acculturative Stress, and Total General Anxiety (N = 47)			
Measure	1	2	3
1. Total Acculturative Stress		.216	046
2. Total General Anxiety	.216		.692
3. Average Familismo	.046*	.692	
*Correlation is significant at 0.05 level (2-tailed).			

Table 2

Pearson Correlations with Familismo Subscales and Total Acculturative Stress & Total General Anxiety (N = 47)				
Measure	1. Familial Support	2. Familial Interconnectedness	3. Subjugation of Self for Family	4. Familial Honor
1. Total Acculturative Stress	.176	.159	.065	.043*
2. Total General Anxiety	.733	.718	.481	.458
*Correlation is significant at 0.05 level (2-tailed).				

APPENDIX A

Thesis Interview Guide

1. Tell me a little bit about your background. (Participant's background)
    a. Where are you from? Where did you grow up?
        i. If not born in the U.S., how was it adapting to a new culture?
        ii. At what age did you come to the United States?
    b. What language are you more comfortable speaking/ what language did you speak at home growing up?
2. Tell me about your family's background. (Family background)
    a. Are your parents from here? If not, where are they from?
    b. What languages do your parents primarily speak?
    c. What education have your parents received? (less than high school, high school diploma, college, etc.)
    d. Do you have any siblings/other family members that live nearby?
3. How has immigration affected your life? What's your experience with immigration?
    a. Were your parents the ones who immigrated here first or did you immigrate with them?
    b. Have your parents had difficulties with immigration or had to deal with discrimination for being an immigrant? Have you had difficulties with immigration or had to deal with discrimination for being an immigrant or being the child of an immigrant?
    c. Do you feel that you had more stress and anxiety in your life due to possible difficulties from immigration?
    d. When/If you had these difficulties, did you have someone to talk to about these experiences? How did you move past them?

4. Tell me about your elementary school, middle school, high school experiences. (K-12 schools)
    a. How did you do in school? Any achievements, any difficult subjects?
    b. When you entered elementary school, how was the school culture different from your home culture? Did your schools have different cultures?
    c. Do you feel you had any difficulties in your academic experience due to immigration?
        i. For example, did stress/anxiety from immigration impact your academics?
        ii. For example, was it harder for you to connect with your peers/teachers?
    d. Did you have any difficulties learning English, if it's not your first language?
        i. Were you in ELL or ESOL?
        ii. If you were in ELL/ESOL, how was your experience?
        iii. Did you ever feel stressed about speaking Spanish at school or that your English wasn't good enough?
    e. How did you feel about your teachers?
        i. How was your school environment?
        ii. Did you have any teachers who supported your culture/didn't support your culture?
        iii. Acceptance of different languages
            1. Was Spanish accepted as a spoken language at your school?
    f. Parental/Familial support
        i. Did your parents meet with your teachers often?
            1. Can you explain why you think they did/didn't meet often?
        ii. How important is it to your parents that you go to college?
            1. What are their educational expectations for you?
        iii. Parents attendance at school functions

5. How's your experience at UNG been? (College experience)
    a. Applying to college
    b. Classes, major, educational difficulties?
    c. Do you feel that UNG has been supportive of your culture?
6. What other educational resources do you wish you had? (Lack of resources)
    a. Did you have any Latinx teachers, counselors, mentors, role models in school?
        i. For example: more bilingual/Latinx teachers, bilingual/Latinx counselors, Latinx mentors and role models, ethnic studies classes
    b. What do you feel your community provides to cope with the stress and anxiety placed on Latinx people from immigration?

Gaia's M-dwarf Gap and the Fully Convective Boundary

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ABSTRACT

Launched in 2013, the Gaia space telescope measured parallax distances to over 1 billion stars. When comparing the brightnesses and colors of stars observed by Gaia, there appears to be a region where the density of red dwarf stars is lower than expected. We explore the structural instabilities that have been theorized to form this region, now called the "Jao Gap". To do this, we created a synthetic population of red dwarfs to mimic the population of stars in the local solar neighborhood. Our synthetic population displays a gap that qualitatively shares many similarities with the observed gap. Notably how bright the stars are in the gap, its slope, and the locations of overdense regions. These results boost our confidence in the physics of current stellar structure and evolution models and provide the first definitive evidence that low-mass stars become fully convective.

BACKGROUND

Launched in 2013, the Gaia space observatory created the most comprehensive and precise 3D space catalogue. To create this catalogue, Gaia monitors the motion of stars. From the motion of each star, a parallax angle can be measured. A precise measurement of the parallax angle is important because this is what allows us to measure how distant a star is.

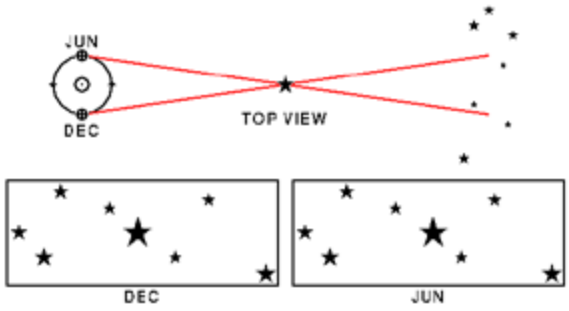

Figure 1: *This illustrates how two measurements are made of the star 6 months apart. The bottom panels show what the star would look like compared to its background stars. Comparing the two panels, you can see the star appears to be moved slightly to the right in the June panel.*

Figure 1 (Wright 2018) gives an example of how the parallax angle is used to measure the distance of a star. The two red lines will give an angle that is on the side closest to the background stars. Using trigonometric relations, we know that is the same angle on the other side as well. The distance from Earth to the Sun has been defined as 1 astronomical unit (au) so we know that distance. Using the diagram in Figure 1, if lines were drawn from Earth to the Sun to the target star that would be a 90° angle. At this point all we have left to do is use the tangent trigonometric relation and we now have the distance from the Earth to the target star. A precise distance allows astronomers to properly quantify a star's intrinsic brightness which we can then compare to other stars. To compare a large quantity of stars, a Hertzsprung-Russell (HR) diagram is used.

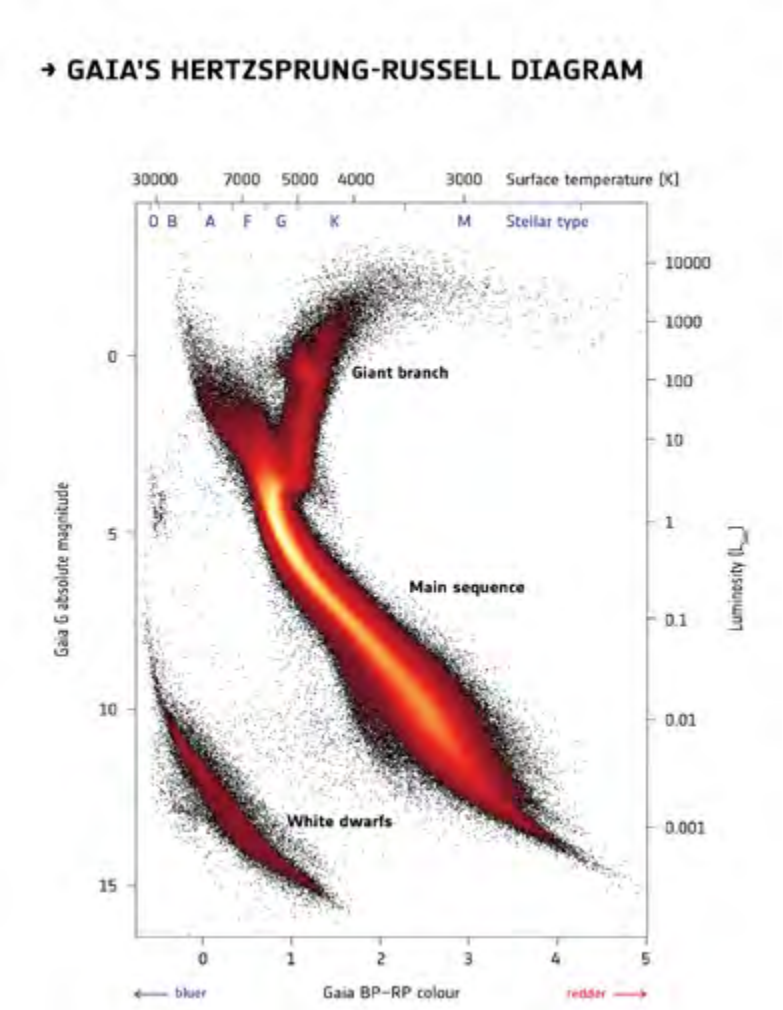

Figure 2: *This is the HR diagram that was created from the measurements made by the Gaia mission. There are over one billion stars being compared in this diagram.*

Figure 2 shows the Gaia HR diagram. In this diagram, over a billion stars are being compared and categorized according to their colors and magnitudes. The color of a star graphically represents its peak wavelength. A hotter star will emit more light at shorter wavelengths. A star that is cooler will emit most of its light at longer wavelengths. Blue stars are very hot while red stars are comparatively cooler. Because of this, color is an excellent indicator of relative temperature amongst stars. Magnitude is simply a measure of how bright a star is. Brighter stars are placed at the top of the HR diagram while dimmer stars are placed at the bottom. Stars with similar traits can be categorized based on their location in the HR diagram.

This thesis is going to focus on M dwarf stars, also known as red dwarfs. These stars are located toward the bottom right of the main sequence. A star's "type" is based on its temperature. The classic spectral types – in order of decreasing temperature – are as follows: O, B, A, F, G, K, M. From this list it can be seen that M type stars are relatively cool, burning at temperatures up to 3700K (6200°F). For reference, our own sun burns at temperatures of approximately 5700K (9900°F) and is a type G star. In the context of this work a dwarf star is going to be defined as a star that is less than 1.2 $M_\odot$. One solar mass is the mass of our sun. The significance of 1.2 $M_\odot$ is that this is about the mass that stars start transitioning from using the proton-proton chain (pp chain) to using the Carbon-Nitrogen-Oxygen (CNO) fusion cycle for converting hydrogen into helium in the stellar core.

The low-mass stars we will be discussing generally use the PP I chain for energy production and nuclear fusion. The chain is as follows.

$$1)\ p + p \rightarrow {}^{2}H + e^{+} + \nu_e$$

$$2)\ p + {}^{2}H \rightarrow {}^{3}He + \gamma$$

$$3)\ {}^{3}He + {}^{3}He \rightarrow {}^{4}He + p + p$$

The PP I chain begins with two protons. The two protons collide and form deuterium, a positron, and a neutrino as shown in Equation 1. In Equation 2, a proton and deuterium collide to form ^{3}He and a gamma ray. In the final link of the PP I chain, equation 3 shows two ^{3}He atoms colliding to form a ^{4}He and two more protons. These reactions are occurring in the core of the star. This energy gets dispersed throughout the star through convection. We are investigating M dwarf stars which have a mass range from $0.08 < M < 0.60$ $M_\odot$. The mass range we are looking most closely at is the fully convective boundary. The masses of these stars lie between $0.28 < M < 0.40$ $M_\odot$. The stars near 0.50 $M_\odot$ are considered partially convective. A partially convective star will only have its energy partially transported by convection. Stars $0.28 < M$ are considered fully convective. A fully convective star primarily transports energy through convection. In a fully convective

star, there is no radiative layer to separate the core convection zone and the surface convection zone hence the entire star is fully convective. In between ~0.28 and ~0.50 $M_\odot$ is a mass range where a star can transition from partially convective to fully convective. These are the stars we will primarily be investigating.

MOTIVATION

In 2018, the Gaia mission had its second major data release, providing precise parallax measurements of over 1 billion stars. Before Gaia, there were reliable parallax measurements for only a few hundred thousand stars. The parallax measurements provided by Gaia increased the population on the HR diagrams, revealing a feature that had never before been seen: a "gap" located near the low-mass mid-M dwarfs.

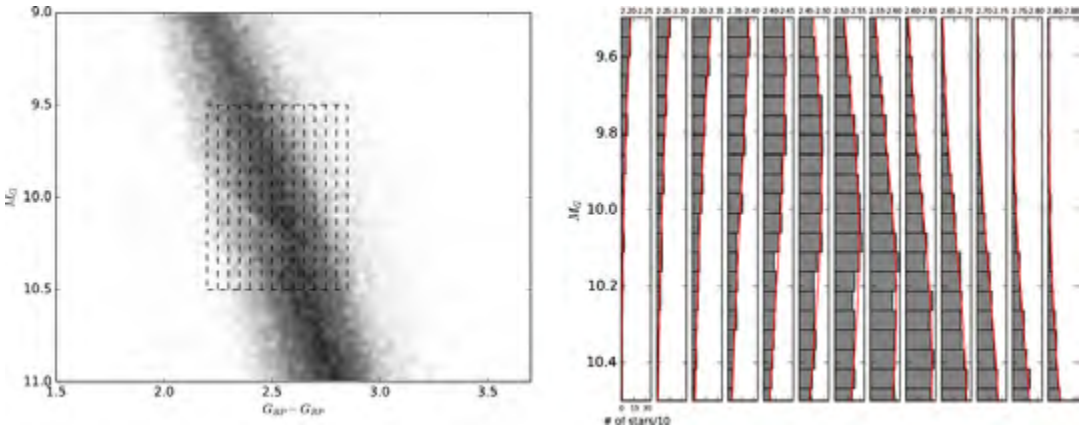

Figure 3.A (left) and 3.B (right): *In Figure 1 the gap is cut into vertical sections along the $G_{BP} - G_{RP}$ color axis. Each cut is 0.05 magnitude wide in color. Figure 2 shows the distribution of the number of stars in each cut.*[1]

The gap is shown in Figure 3.A in the range from about $2.2 < (G_{BP} - G_{RP}) < 2.8$ and $M_G \sim 10$. The gap is a statistically significant drop in the density of stars compared to its surrounding regions in the HR diagram. Figure 3.B shows how the density of the stars changes as you approach the gap. The density drops by ~10% in the $2.2 < (G_{BP} - G_{RP}) < 2.8$ range. In order to verify that the gap was not simply an error in the data, Jao et al. cross matched the Gaia and 2MASS catalogues and verified that the gap faintly appeared in the 2MASS catalogue as well.

When looking into the origin of the gap, Jao et al. (2018) concluded that the gap is most likely linked to the transition to fully convective stars. This was evidenced by the fact that, not only did the isochrone models show that the gap appeared approximately in the 0.35 $M_\odot$ and solar radii range, but the gap is narrow, which signals that the change is sudden. The size and location of the gap, being narrow and near the predicted convective transition zone, is strongly indicative that the gap is the result of stars transitioning from partially convective to fully convective.

MacDonald and Gizis (2018) conducted a study on the convective boundary. Their results showed that during a star's transition from partially convective to fully convective, there is a single convective episode that causes the luminosity and radius of stars $M_{\odot}$ ~.034 to grow and shrink. Another study conducted by Baraffe and Chabrier (2018) appears to contradict the results of MacDonald and Gizis (2018). When Baraffe and Chabrier performed the study their results showed that multiple convective episodes occur. Both groups concluded that the physical explanation for the gap is due to non-equilibrium ^{3}He fusion.

Van Saders and Pinsonneault (2013) investigated this instability near the fully convective boundary. Their results showed that when stars transition to fully convective, the radiative layer disappears and the core and surface convection zones merge. Van Saders and Pinsonneault's (2012) study concluded that near the fully convective boundary stars with ~0.35 $M_{\odot}$ start building up ^{3}He in their cores leading to what Van Saders calls the "convective-kissing instability". This buildup of ^{3}He is due to the temperature requirement for ^{3}He to undergo fusion to ^{4}He. Low mass stars do not get hot enough for this fusion to occur rapidly. Because of this, ^{3}He builds up in the core of the low mass stars creating a non-equilibrium. In an attempt for the star to continue ^{3}He fusion, the core contracts which will increase the production of ^{3}He. This extra energy that is produced will cause the convective core to expand. As ^{3}He reaches an equilibrium value, meaning that it is being destroyed as fast as it is being produced, the core and surface convection zones merge. When the two zones meet, some of the ^{3}He in the core will flow to the envelope through convective mixing causing the convective core to shrink. When the convective core shrinks, the radius and luminosity of the star also decrease. These changes in radius and luminosity create a lower density region in the HR diagram that we now know as the Jao Gap.

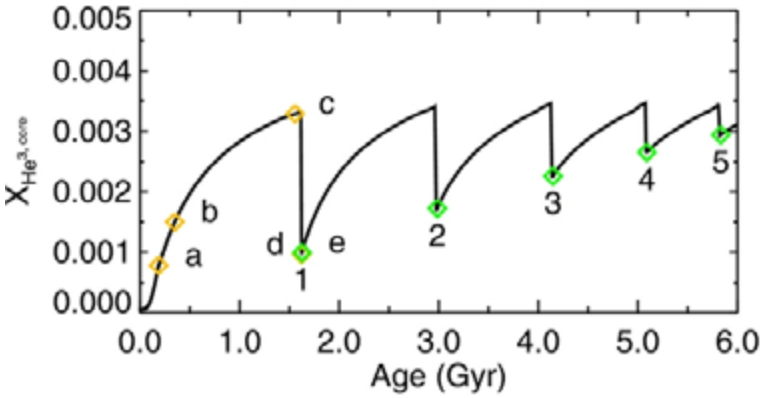

Figure 4: *This plot shows how the abundance of ^{3}He in the core changes over time. Each dip in the plot signifies a convective episode. Over time the severity of the drops decreases as the core and surface convection zones move to ^{3}He equilibrium.*[2]

Figure 4 gives an illustration of the core ^{3}He abundance over time. Each of the sharp drops signifies a convective kissing episode where the two convection zones merge. After the convective core shrinks from the loss of ^{3}He and the star becomes partially convective, the core convective zone begins to build an abundance of ^{3}He once more. Over time the decrease in core ^{3}He becomes less severe, this is because the core convection zone and envelope are getting closer to having equal abundances of ^{3}He so the difference in ^{3}He quantities between the two convective regions starts to lessen. These results are nearly identical to the results of the Baraffe and Chabrier experiment.

Combining the results of the Van Sader experiment with the Baraffe and Chabrier study we can see a potential link between the convective kissing instability and a drop in the luminosity function that could potentially create a dip. With the convective kissing instability we can see in Figure 4 how the ^{3}He dips continuously through each episode. Each dip sees a sharp drop in both luminosity and radius at the same time which will cause a star to move down on an HR diagram. Each buildup causes the luminosity and radius of a star to increase. This movement can cause an under density of stars at the luminosity where the instability occurs producing a gap like feature.

The results of these previous studies suggest that the gap is related to the fully convective boundary. However, the complete morphology of the gap has yet to be modeled due to the fact that in each of these studies, a solar metallicity was used. When comparing two stars with identical features, but two different metallicities, the star with a higher metallicity will appear to be redder and cooler. The addition of varying metallicities could impact various features such as slope, overdensity area, shape etc., of the gap generated by the synthetic HR diagram. In order to get a more complete morphology of the gap, a synthetic HR diagram is needed. If models can accurately recreate the morphology of the observed gap then we can be more confident that the "convective-kissing instability" is the root cause of the gap.

In this study, we synthesize a population of stars in the solar neighborhood, testing whether or not our stellar evolution models can accurately recreate the observed Jao Gap. Ultimately, the goal is to compare the metallicity relationship of the ^{3}He instability with the observed gaps HR diagram placement. This could in turn provide further evidence supporting the hypothesis that the ^{3}He instability creates the gap potentially shedding a light on the overall accuracy of the input physics on current stellar models.

METHODOLOGY

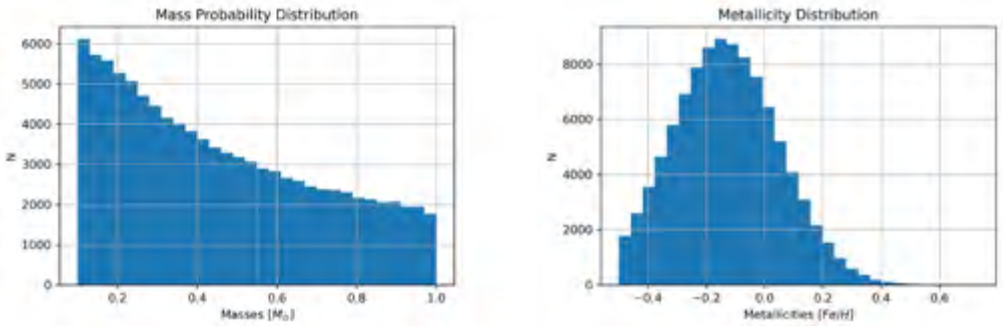

Figure 5.A (Left) and Figure 5.B (Right): *On the left is the distribution of masses generated from the Chabrier IMF. On the right is the distribution of metallicities generated from the distribution given by the Geneva Copenhagen Survey. The distribution is a Gaussian curve with a -0.14 mean and dispersion of 0.19 dex.*

When attempting to recreate the gap, the first task was to synthesize a population of stars in the solar neighborhood. Synthesization of these stars requires an input of mass, metallicity, and age values. To generate masses, population synthesis was conducted using monte carlo methods. The initial mass function (IMF) is the probability distribution of stars for every given mass. This is important because an improper density of any mass could vastly change the population density of any area on the synthetic HR diagram. The IMF chosen was the Chabrier IMF. The reason for this is that not only is it the most recent, but it is also one of the only IMFs that support masses below 0.50 $M_{\odot}$. While the Kroupa IMF also supports stars below 0.50 $M_{\odot}$, it slightly overestimates M-dwarf densities (Chabrier 2003). Because M-dwarfs are the main focus of this study, the more accurate Chabrier IMF was used. The distribution used to populate the synthetic HR diagram is shown in Figure 5.A.

Metallicities were generated using a normal distribution with [m/H] = -0.14 ± 0.19 dex found from the Geneva Copenhagen survey (Nordstrom et. al 2003). The advantage of using the Geneva Copenhagen Survey distribution (2003) as opposed to the Schuster & Nissen distribution (1989) stems from nearly a decade and a half of improved technology. More specifically, the use of more spectroscopic calibrators. It was pointed out that the Shuster & Nissen distribution had many errors in the redder type G stars and the type K stars (Twarog et al. 2002). When the metallicity distribution was recalculated using more modern instrumentation, the systematic errors in the metallicities were corrected (Nordstrom et. al 2003). The metallicities of type K and type M dwarfs should not vary drastically so this distribution is used to generate metallicities. The metallicities distribution used when generating the synthetic HR diagram are shown in figure 5.B.

When generating the ages for our synthesized population we chose to limit the stars to between 500 Myr and 10 Gyr. 500 myr is about the time when most M-dwarfs are predicted to have entered the main sequence. Because the Jao Gap is found on the main sequence, that is the minimum age that we are computing. For the maximum age, the galactic thick disk was recently found to have a mean age of approximately 9.2 - 10 ± 0.25 Gyr (Sanjib et. al 2019). M dwarfs have the fuel capacity to exist for trillions of years so it is possible for a population of them to have an age of 10 Gyr. Given this information, it can be safely deduced that an age of 10 Gyr should suffice for our synthetic HR diagram. From this age range of stars, a uniform age distribution was created.

Using combinations of the random ages, metallicities, and masses synthesized above, stellar properties were determined within a fine grid of stellar evolution models. The models used are based on the Dartmouth Stellar Evolution Program (Dotter et al. 2008; Feiden, Roberts, & Edvardsson 2020). The grid used in this study adopted the composition of Grevesse, Asplund, & Suaval (2007; GAS07), which specifies that the Sun has a metal mass fraction of Z = 0.013.

More recent studies of the solar atmosphere have concluded that the composition is fairly close to the GAS07 model. The difference being that new data shows the solar atmosphere is slightly more metal rich (Asplund et al. 2009; Caffau et al. 2011). While there are more recent models than the GAS07, MARCS model atmospheres, which are used to specify surface boundary conditions, are calculated with the GAS07 solar composition. When comparing MARCS/GAS07 with the newer PHOENIX/AGSS09 (Asplund, Grevesse, & Suaval 2009) the differences between surface boundary conditions were negligible so we continued to use MARCS model atmospheres and the GAS07 solar composition (Feiden, Roberts, & Edvardsson 2020).

Mass tracks for the grid were computed between $0.08 < M < 0.80\ M_{\odot}$. A mass increment of $\Delta M = 0.005$ was used for $0.08 < Msun < 0.20\ M_{\odot}$, $\Delta M = 0.01$ for $0.20 < M < 0.28\ M_{\odot}$, $\Delta M = 0.005$ for $0.28 < M_{\odot} < 0.36\ M_{\odot}$, and $\Delta M = 0.02$ for $M > 0.36$. The higher resolution areas of 0.005 M increments were chosen to resolve the ^{3}He instability (van Saders & Pinsonneault 2013; MacDonald & Gizis 2019). Mass tracks were computed with metallicities $-0.5\ dex \leq [m/H] \leq +0.5\ dex$ with 0.1 dex resolution.

DATA AND ANALYSIS

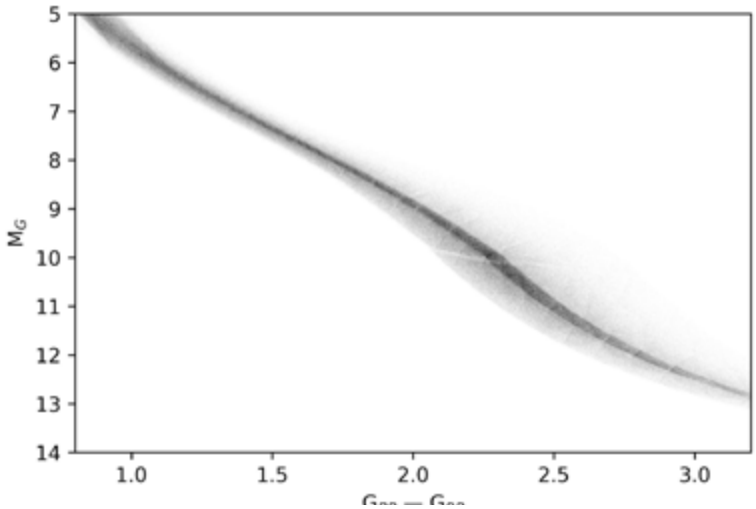

Figure 6: *This is the synthetic HR diagram. The biggest difference between the synthetic diagram and the observed diagram is the slight blue curve that occurs for lower mass stars. The diagram was created by making a 2d histogram.*

Figure 6 shows the HR diagram created from the population synthesis. It was generated by creating a 2D histogram from the synthetic data with 1000^2 bins. The darker areas indicate a higher density of stars while the lighter areas indicate a lower density. The synthetic HR diagram is similar to the Gaia HR diagram for higher mass stars. However at M_G ~8.0 the synthetic HR diagram and Gaia HR diagram diverge with the synthetic diagram bending towards blue colors creating a shift that continues for the rest of the main sequence.

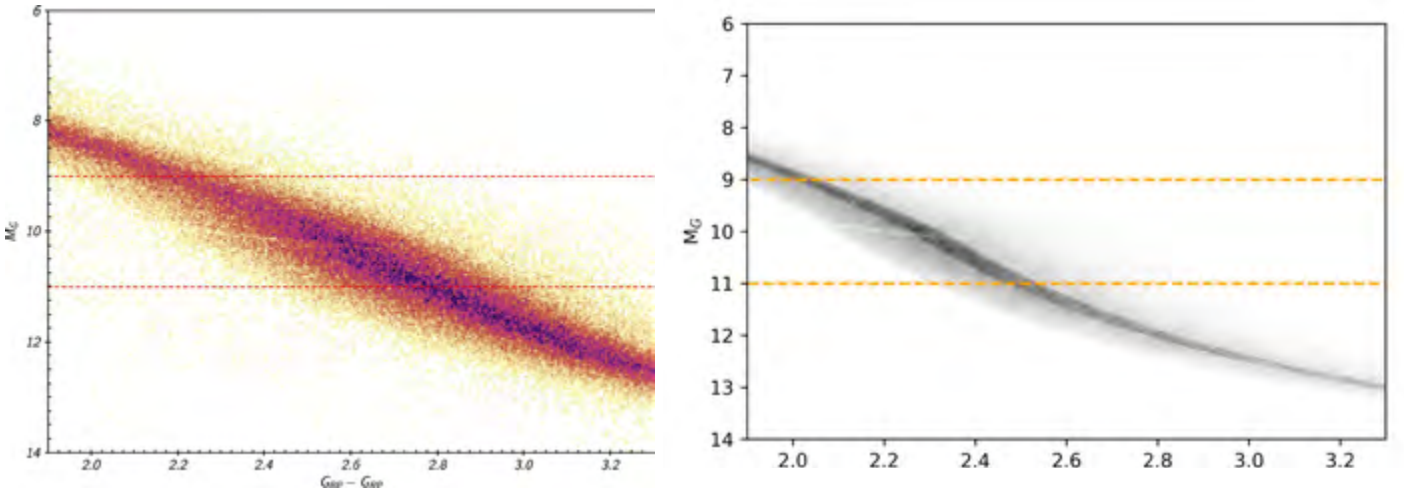

Figure 7.A (Left) and Figure 7.B (Right) : *The left image shows the observed Jao Gap while the right image shows the Synthetic Gap. While the two gaps are qualitatively very similar, there are still slight differences.*

The observed gap can be seen in figure 7.A, while the synthetic gap can be seen in Figure 7.B. For further clarity, lines have been placed above and below both gaps. One of the differences between our models and observed stars is a slight shift towards bluer color bands in the models. This can be seen when comparing Figures 7.A and 7.B. The synthetic HR diagram is shifted towards the blue band (G_{bp}-G_{rp}) ~ 0.1. This is an indication that our models for low-mass stars are not entirely correct.

Another interesting difference that was seen in the synthetic models is the appearance of smaller gaps or "gaplets". These gaplets make appearances at M_G > 11. While not obvious in the original Gaia M dwarf paper, under densities that are similar in shape at similar magnitudes have been spotted in a more recent Gaia CMD with a higher star count. While we recognize these gaplets exist, exploring their physics is beyond the scope of this thesis which is to characterize the main gap.

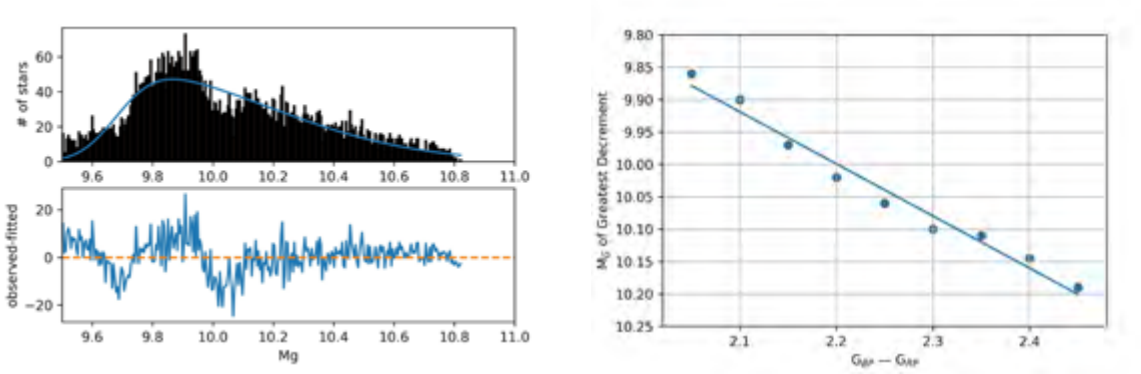

Figure 8.A (Left) and 8.B (Right): *The top left shows a fitted line over a histogram of stars within the synthetic gap. The bottom left shows the residuals from the histogram on the top left. The gap is easily seen on the residuals plot at ~ 10.05 Magnitude. The plot on the right shows our models prediction of the synthetic gaps slope. The synthetic gap is predicted to have a slope of 0.81 3 0.04 while the observed gap is measured to have a slope of 0.82 3 0.05. These results show that the slopes of the two are very similar.*

Looking further at the synthetic models, Figure 8.A gives a clear graphical representation of the synthetic gap. The histogram in Figure 8.A was created from a strip of stars at (G_{bp}-G_{rp}) = 2.25 and was Δ(G_{bp}-G_{rp}) = 0.05 in width. To calculate the slope of the gap we calculated the point of greatest decrement from the histogram. The easiest way to do this was using the built in skewed gaussian fitting tool from Lmfit. A line was fit over the data and we looked at how much the histogram differed from the line. The plot below the histogram looks at these differences also known as residuals. The residuals show a sharp decrease of stars at M_G ~10.05 which signifies the gap. After identifying the magnitude of greatest decrement a gap a slope was able to be extracted. Figure 8.B shows the calculated slope from the models. To calculate the slope, we again separated the gap into vertical strips that were Δ(G_{bp}-G_{rp}) = 0.05 in width. We then created a histogram from each strip and fit a line over the histogram. In each fitted histogram we marked the magnitude that had the

greatest decrease in total number of stars. To get a more accurate fit line, we trimmed the data to contain points around the visual gap to avoid confusion from other physical processes or numerical artifacts that could create artificial gaps. This removes any extraneous values that would shift the fit line of the histogram. With trimming, we fit the data based on the gap and magnitudes directly above or below it. The synthetic gap was calculated to have a slope of 0.81 ± 0.04 while the observed gap has a slope of 0.82 ± 0.05. The slopes are identical given the uncertainties.

DISCUSSION

Can our stellar models recreate the gap?

The results of our study show that the gap can be recreated fairly accurately. The morphology of the synthetic gap is consistent with the observed gap. Qualitatively the slopes of the synthetic gap and observed gap are comparable. Because the gap is such a fine feature, the fact that we can accurately synthesize such a close replica suggests that the physics of current stellar models are largely correct. One of the biggest differences between the two is that the synthetic gap has a slight shift towards the blue color band. This, however, is a known problem. Rajpurohit et al. (2013) found that there appears to be missing opacities in the blue portion of HR diagrams corresponding to late M-dwarfs. This could be attributed to some error in calculating either the synthetic photometry or the interior physics. Either way, our study is not able to conclude which is at fault: interior or atmospheric physics.

Is the gap metallicity dependent?

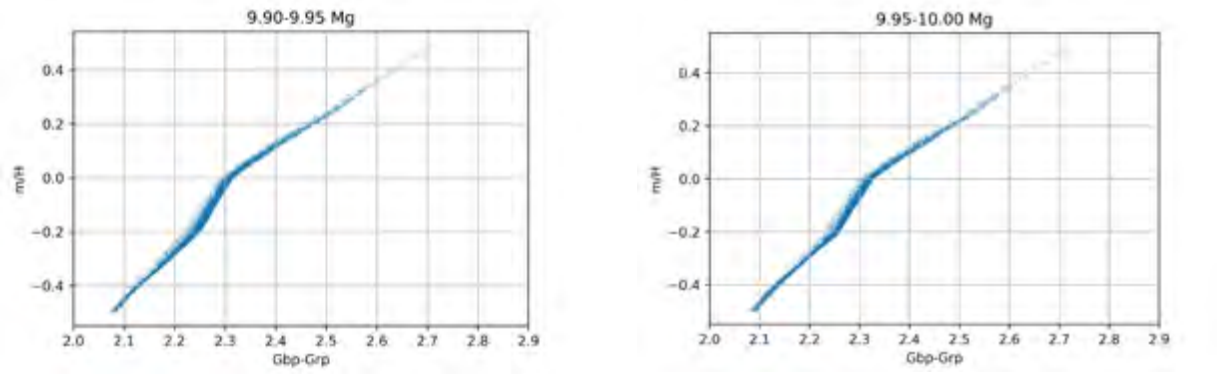

Figure 9: *These graphs show how the metallicities of the stars within our synthetic HR diagram change as we move across the (G_{bp}-G_{rp}) axis. The gap can be seen at (G_{bp}-G_{rp}) ~2.13 in the left graph. When we look at the next strip the gap appears at (G_{bp}-G_{rp}) ~2.17.*

Figure 9 shows how the metallicity of the gap evolves as we move across (G_{bp}-G_{rp}). While not completely obvious if you only look at one graph, comparing the two reveals what appears to be a metallicity relationship with the formation of the gap. In both metallicity evolution graphs, a pinching point can be seen where the gap is located. In the left figure this can be seen at (G_{bp}-G_{rp}) ~2.13 and in the right figure at (G_{bp}-G_{rp}) ~2.17. In each graph, there is a smaller number of stars both above and below the main curve at each point. Further modeling showed that a relationship lies between the metallicity and the PPI chain activation of the star. The reason for this is that metallicity can impact the opacity of a star which will impact its overall temperature. The overall temperature is what controls the rate of ^{3}He production and destruction which in turn can shift the fully convective boundary lower or higher. A higher metallicity star will have a higher opacity leading to a higher temperature. A lower metallicity star will have a lower opacity leading to a lower temperature. Models show that the fully convective boundary occurs in lower mass stars at lower metallicities and higher mass stars at higher metallicities.

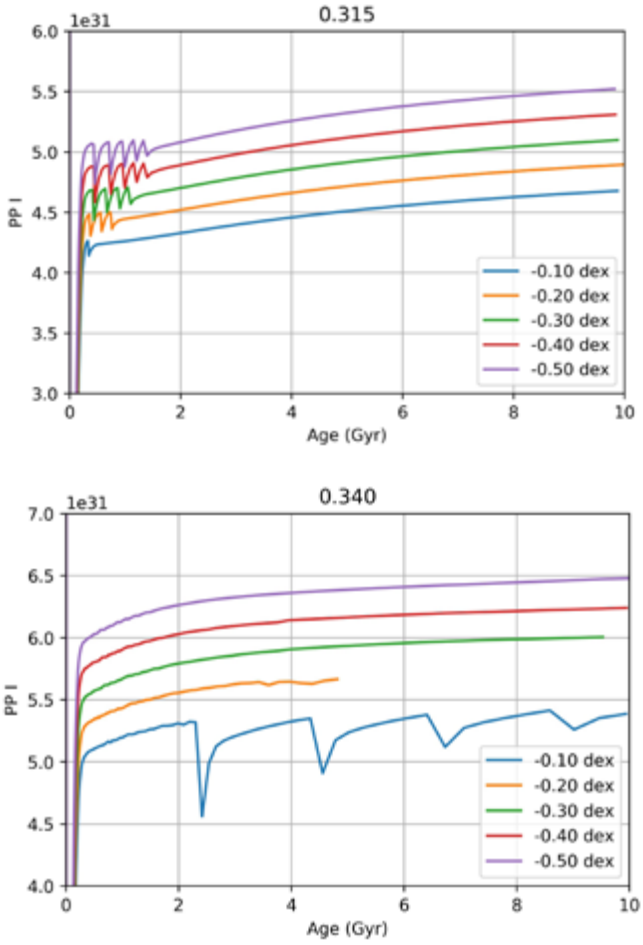

Figure 10: *These graphs compare PP 1 chain activation within different metallicity stars. Metallicity is logarithmic and can be measured with dex values. For example -1.0 dex will mean the star has a metallicity of 10 times less than our sun. The jagged lines indicate that the instability is occuring while the smooth lines indicate the star is stable.*

This is illustrated in Figure 10. The transition from partially convective to fully convective begins to occur at 0.315 $M_{\odot}$. At -0.10 dex Metallicity the instability does not have near the activity as it does with the -0.20 dex stars and above. We can see that the dips occur at lower metallicities for the low-mass stars and higher metallicities for the high mass stars.

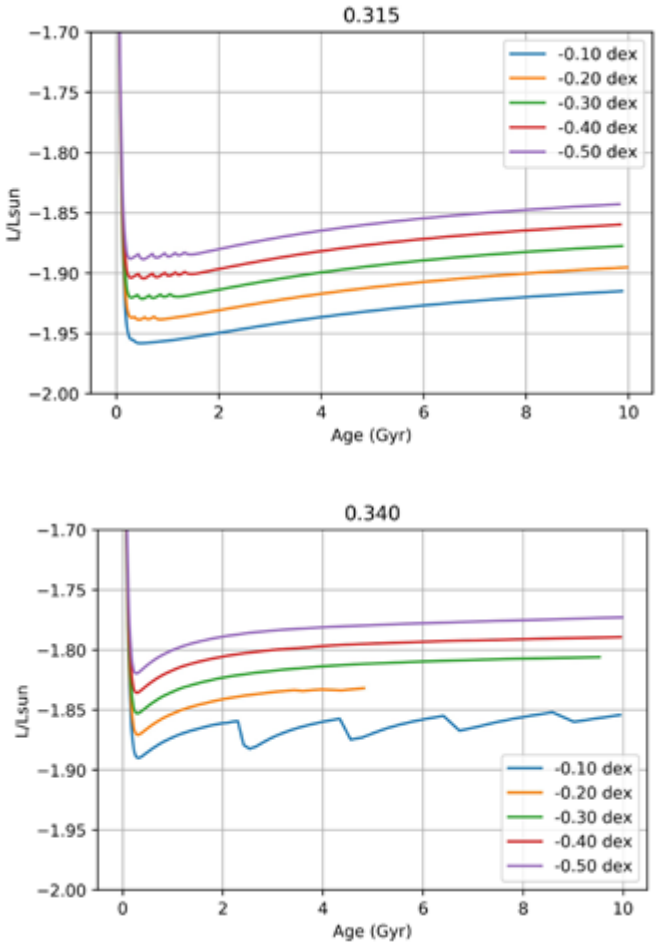

Figure 13: *The relationship between mass and metallicity can also be illustrated by the luminosity to show that PPII chain activation is related.*

To better see how this could actively impact stars on an HR diagram we can see this mass/metallicity relationship when looking at the luminosity as well. At 0.315 $M_{\odot}$, the luminosity barely changes at -0.10 dex. As the metallicity gets lower though, the dips become much more visible and we can clearly see the instability occurring. At the end of the instability mass range, we can see at -0.10 dex that the instability continues to occur. It is only with lower metallicities that the luminosity shows no visible fluctuation.

Is the gap a result of the instability?

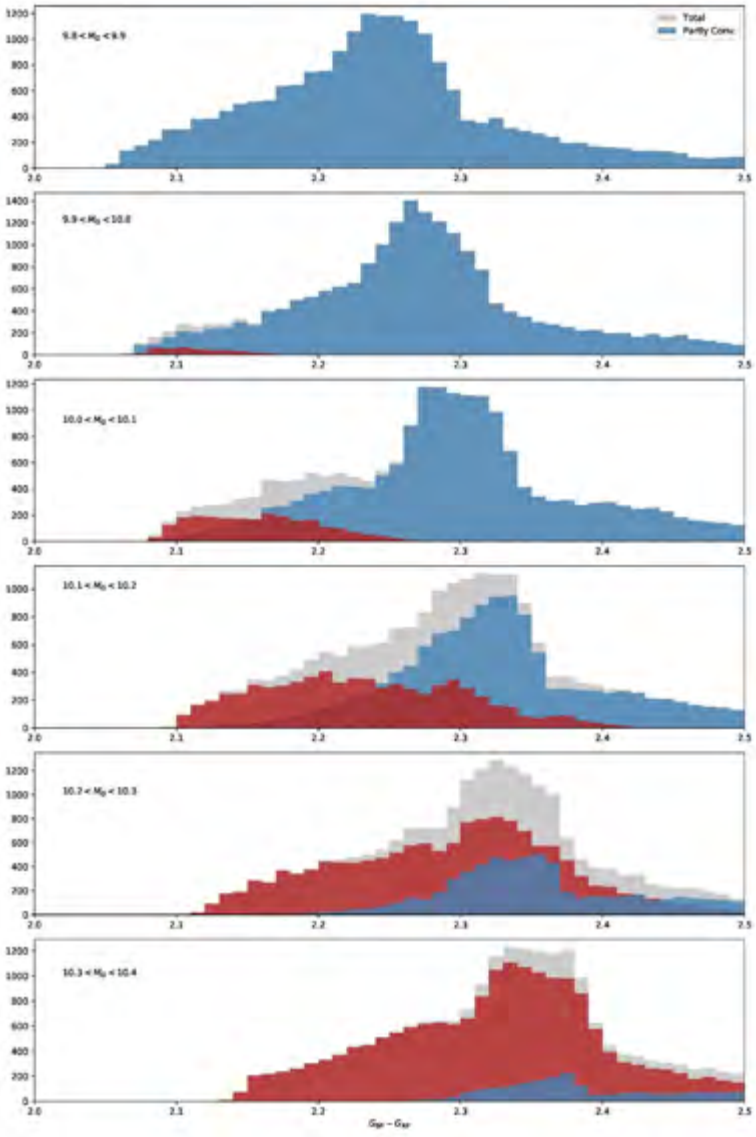

Figure 12: *Histograms were created to compare the amount of partially convective and fully convective stars as one looks at the gap. The top histogram represents the very beginning of the gap. Each successive histogram represents a new strip of stars within the gap in 0.05 magnitude increments. The arrow in each histogram represents the location of the gap at that point.*

Our results show conclusively that the gap is a product of the convective kissing instability (Van Saders & Pinsonneault 2013). This is illustrated in Figure 12. Looking at each histogram shows that as we move deeper into the gap, the total number of fully convective stars are increasing. As the number of fully convective stars increase, the number of partially convective stars are decreasing. It appears that the partially convective stars are transitioning to fully convective meaning that the convective-kissing theory put forth by Van Saders is correct.

The physical processes behind the convective-kissing instability begin with the proton-proton chain. This is the main form of energy production for low mass stars. The chain begins with two hydrogen nuclei undergoing a reaction and being converted into a deuterium nucleus, . Next a proton capture reaction occurs converting the deuterium nucleus into helium-3, . The main fact to note with this reaction is that it is able to occur at a significant rate at relatively low temperatures. Low temperatures are important because the next reactions in the proton-proton chain only occur at a significant rate at much higher temperatures (Parker, Bahcall, & Fowler 1964). Low mass stars have relatively low temperature cores, so in M-dwarfs, ^{3}He is created at a much higher rate than it is destroyed. Consequently this causes a build up of ^{3}He in the core of the stars. In order for the star to maintain pressure and temperature equilibrium, the core must increase in size. This will increase both the radius and luminosity of the star. Eventually the core gets big enough to overcome the radiative layer and plasma from the core convection zone and surface convection zone will mix. The surface convection zone at the beginning of this cycle has a much lower abundance of ^{3}He than the core. When the two plasmas meet ^{3}He in the core flows and convectively mixes into the surface of the star. This drop in ^{3}He means that the core will have to shrink again to maintain equilibrium. Once the core shrinks, both the radius and luminosity of the star decrease as well. The two zones become separate again and the cycle continues until there is an equal abundance of ^{3}He in both the core convection zone and surface convection zone.

FUTURE WORK

Varying Age Distributions

To confirm the appearance of the gap and Van Saders convective-kissing instability our models used an even distribution of ages. The gap appeared in the synthetic HR diagram and compared fairly well to the observed gap. Because the observed gap is such a fine feature in HR diagrams, we could use the synthetic gap to test current stellar model parameters. To confirm the appearance of the gap and Van Saders convective-kissing instability, our models used an even distribution of ages. In the future, it may prove fruitful to run more models using the age distribution put forth by the Geneva Copenhagen survey. Preliminary models have been run with skewed ages. The addition of skewed ages actually changes the overdensity regions on the edge of the synthetic gap. A detailed analysis has not yet been conducted but a more in depth study could be used to further calibrate current age model estimates.

Addition of Magnetic Fields and Starspots

This study did not include the effects of magnetic fields or starspots at all. Magnetic fields and starspots generally decrease the luminosities and effective temperatures of stars which could explain some of the inaccuracies of the models. Lower effective temperatures and luminosities could cause the low mass models to red shift which would fix the blue shift error of current models.

CONCLUSION

We have successfully modeled a gap that qualitatively shares many similarities with the observed Jao Gap. We have also provided strong evidence that supports the convective-kissing instability is responsible for the creation of the Jao Gap. Both the general shapes and the slopes of each gap are comparable. One key difference is the blue shift of the synthetic gap but in future studies we plan to add starspots and magnetic fields to see if this shift can be corrected. We also plan in the future to see the effects of a varied age distribution in the formation to potentially test the accuracy of the current distribution.

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Towards Use of Chemically Selective Thin Polymer Films for TXRF Detection and Regeneration for Cr(VI)

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ABSTRACT

Chromium most often exists in two natural oxidation states, Cr(III) necessary for life and Cr(VI) a carcinogen. To detect lower levels of the heavy metal and to distinguish between oxidation states, use of polystyrene coated, pyridine functionalized polymer chemically selective films with Total Reflection X-Ray Fluorescence (TXRF) was proposed using a new protocol to potentially lower limits of detection and increase selectivity. Thin polymer films were cast onto a sample holder and exposed to solutions of acidic Cr (ppb range) to preconcentrate Cr(VI) in the films prior to analysis. TXRF analysis of bound Cr(VI) is performed and followed with a chemical regeneration under basic conditions. Gold nanoparticles act as an internal standard for potential quantitative TXRF analysis and to assess film viability. Through the regeneration process, films are predicted to be reusable, chemically selective sensors for Cr(VI) when coupled to TXRF. A variety of film development protocols were tested and a comparative study of standard deviation and RSD for Cr(VI) uptake and regeneration was performed. Results show progress towards a smaller RSD and deviation with room for improvement.

INTRODUCTION

Chromium (most often in its oxidation states of III and VI) is detected within water purity tests in low levels. Cr (III) is necessary for life as a trace metal within humans, but Cr (VI) is a carcinogen to the human body.[1] Thus, differentiating between these oxidation states in trace amounts in the perspective of water purity is desired. Current limits of quantifiable Cr in water is at 100 ppb according to the EPA. If this entire amount is composed of harmful Cr (VI), long exposure to this level of contaminant can begin to produce adverse effects.

To differentiate between oxidation states, chemical selectivity for hexavalent chromium was proposed. Previous electrochemical sol-gel methods with pyridine functional groups lacked reproducibility, thus directions have moved towards thin films cast onto glass slides. Chemical selectivity is achieved through the use of polyvinyl pyridine to form polymeric films with similar pyridine functional groups.[2] To protect films and maintain their viable usage time, a Cr(VI) permeable protective polystyrene film is applied over the sensing film.[3] The cycle of Cr(VI) through the film's functional group structure can be seen in *Figure 1.* The films also contain an addition of gold nanoparticles to be used as an internal standard and an indicator of films quality. The films are analyzed through TXRF to detect a ratio between the gold nanoparticles and the up taken Cr (VI). A regeneration is then performed through a basic solution and the films are analyzed again to observe effective removal of the Cr (VI). All three steps can be seen in *Figure 3.*

METHODS

Solutions were made by the following protocols. Gold nanoparticle solutions (AuNP) were made through mixing 6 mg of $HAuCl_4$, .0209 g $Na_3C_6H_5O_7$, and 24 mL H_2o. After mixing, AuNP were covered with foil to protect from light. Poly(4-vinylpyridine) (60,000 average molecular weight) (PVP) solutions were made by mixing .1000 g of PVP with 25 mL of methanol with a stir rod and plate for 5-10 minutes. A 1% polystyrene solution (average molecular weight 192,000) (PS) was made by dissolving .2068 g of PS beads in 21.8535 g of toluene with stirring, sonication, and shaking in a sealed vessel. Film solution of PVP and AuNP was made through addition of 5 mL of PVP solution and 25 µL of AuNP solution (FS). An additional solution of PVP and PS (PVP/PS) together in a 1:8 ratios was made in toluene to test a more effective annealing of the film to the glass slide. However, issues with this solution occurred when 300 µL of the AuNP solution was added, causing a crashing out of the two polymers (most likely the PS). Ratios were tested in ranges of 1:1, 1:4, and 1:8 of each polymer solution.

Before film casting, 1-inch diameter glass slides were pre-treated with chlorotrimethylsilane 98% (CTS) by immersing for 15 seconds, air drying for 10 seconds, and then baking in an oven for 30 minutes at 100° C. Treated slides were washed with deionized (DI) water and wiped dry. To cast films, various methods were attempted. First, 10 µl of FS was cast onto center of glass slides and allowed to dry to a slight white color over the course of 5 minutes for all methods with the exception of the PVP/PS solution. This solution with the AuNP solution incorporated was deposited in 10 µL portions as well and allowed to dry for 10 minutes. After drying, the variance in the methods can be seen.

Method 1	FS solution, air dried 5 min.
Method 2	PVP/PS solution, air dried 10 min.
Method 3	FS solution, heat annealed for 5 minutes
Method 4	FS solution, 10 uL PS coating (2x), air dried for 5 minutes
Method 5	FS solution, 10 uL PS coating (2x), heat annealed for 5 minutes

Slides for each method can be seen in *Figure 6*. For films with PS solution overcoats, 2 additions of 10 µL of PS solution was added over films, ensuring all edges of films are within PS coating as seen in *Figure 2*.

For Cr (VI) testing and calibration curve formation, method 4 was employed. Glass slides with films were floated on the surface of 10 mL of Cr solution (ranged from 10.493 ppb, 50.967 ppb, 101.135 ppb, 303.606 ppb, and 508.474 ppb Cr) with a stir bar underneath. The films were faced down and in contact with the solution. Stirring at 200 rpm, the slides were exposed to the analyte solution for 10 min. Slides were then removed and washed with DI water and patted dry around the film. A TXRF run was then performed with a 500 second run time. Ratios of Cr (K12 peaks) to gold (L1 peaks) were noted (peaks seen in *Figure 3*) and the same trial was run twice more, rotating the slide 120° each run to achieve a triplicate average ratio. Slides were then regenerated by floating on the surface of 10 mL of 50 mM NaOH with stirring beneath at 200 rpm for 10 minutes and after removal, were rinsed with DI water. Another TXRF run was performed in triplicate to observe the changed Cr/Au ratio. This was performed for each concentration to create a partial calibration curve seen in *Figure 4*. In higher concentration regenerations, the Cr removal is more effective but the AuNP internal standard also began to leech out.

Due to the large error bars within the partial calibration, a comparative study between methods was performed to observe standard deviations and RSD values. Each method seen above followed the following test protocol for comparison. Slides were rinsed wit DI water and patted/air dried. A presoak TXRF run was taken to ensure incorporation of the gold nanoparticles and to ensure lack of a chromium peak. Runs were taken in triplicate for each method. Slide were then soaked for 10 minutes in 499.68 ppb with slides face down and stir bars circulating at 85 rpm. Slides were rinsed again with DI water and patted/air dried. TXRF runs in triplicate were taken again before regeneration with 10 mL of 50 mM NaOH for 10 minutes. Final TXRF runs were performed in triplicate again. Standard deviation and RSD was determined for the presoak, soak and regeneration steps between the runs in triplicate.

RESULTS

A partial calibration was achieved with 1 polymer film, each trial run in triplicate, and a calibration plot created as seen in *Figure 4*. Concentrations of 0 ppb, 10 ppb, and 50 ppb Cr solutions were run with 1 regeneration between 10 ppb and 50 ppb. A Q-test was performed at 95% confidence for each ratio value with one value being tested out (in the 10 ppb trial). RSD percentage for each trial was as follows:

[Cr]	RSD in PPT
0 ppb	32.6456
10 ppb	4.0839
50 ppb	138.4194
10 ppb regeneration	425.9012

The comparison study yielded a range of results for RSD in parts per thousand that can be seen in *Figure 7*. This comparison study calculated the ratio of Cr/Au for each TXRF run, with RSD calculated for each of the 5 methods. The RSDs between pre-soak (clean slides with film), soak (soaked in Cr solution), and regenerated (basic solution treatment) were shown between each method as well.

DISCUSSION

Solution concentrations were optimized first through concentration of PVP solution. Variations included .1, .2, .3 and .4 g in 25 mL methanol to observe best annealing to glass but uptake of Cr was limited due to the film flaking off at higher concentrations. Gold nanoparticles were optimized at 10% by volume for detectability purposes while not flooding signal of Cr(VI). Film volume was optimized at 10 µL as smaller volumes did not provide an adequate signal of Cr(VI) due to limited uptake, however larger films spread the concentration of Cr(VI) over a larger surface beyond the detection radius of the TXRF.

Variations in ratio values could arise from irregularities in the films due to uneven polymer adhesion to the glass (as seen in *Figure 5*) but possible corrections could be solved by performing the measurements in triplicate or more. Between multiple slides, surface area differences on film can vary as well which is why a ratio of Cr to Au was implemented. The partial calibration curve exhibits this irregularity which led to the method comparison study.

The comparison between methods allowed quantitative determination of improvements to overall chromium uptake, detection, and removal. Regular PVP films were moderately effective, but the PS coated films were shown to be more effective. Films without PS coating exhibited comparable uptake of Cr but did not have stability and was consistently unstable after several soaks (which removes the possibility of recyclability needed for effective calibration).

Higher concentration base regeneration was also explored with 1 M NaOH vs the 50 mM traditionally used. However, while more basic solutions removed Cr more effectively, is also favored the leeching out of the AuNP internal standard. This comparison can be seen in *Figure 8*.

CONCLUSION

While RSD values from partial calibration indicate large variances in the film structure, this was somewhat expected due to irregularity of the polymer film. Future corrections would include an optimization of individual film runs beyond triplicate runs. However, the risk of extended analysis time to complete the calibration could defeat the feasibility of this protocol being applicable. Approaches to create a more uniform film or more uniform Cr uptake were investigated to potentially decrease the high RSD values from film variation, as well as aid in Cr(VI) uptake and signal quantification. Comparative data of RSD and standard deviation values from this study do not yield significant results, but do show a trend of increasing viability with more modifications. Future directions point towards a similar concept of chemical selectivity, but replace pyridine functional groups on glass slides with thiolated pyridine functional groups to bind to gold on quartz crystal microbalance (QCM) slides. With this direction, actual mass monitoring could be observed as the film is deposited onto the gold surface. Due to the sensitivity of this concept, Cr(VI) uptake may also be within the range of detection so this would allow for double confirmation of Cr(VI) uptake and regeneration through QCM and TXRF.

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FIGURES:

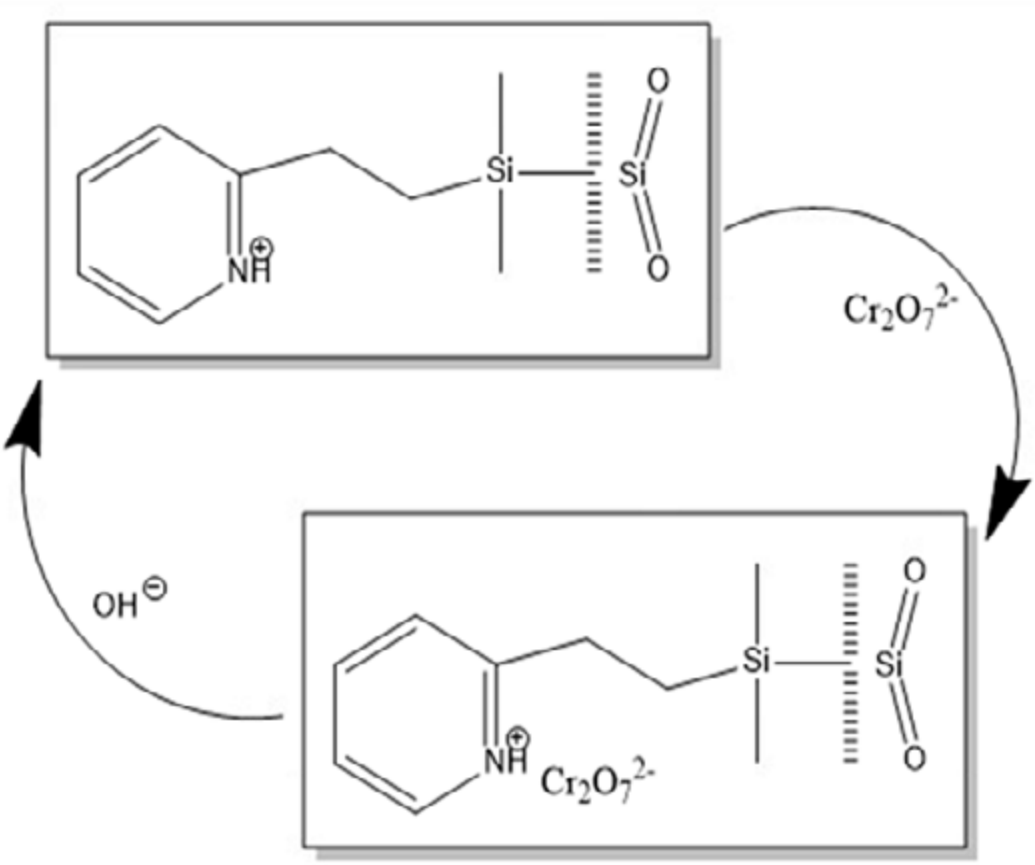

Figure 1. Cycle of Cr(VI) to pyridine functional groups and regeneration of functional group with base.

Figure 2. Slides with PVP films (white) and PS coating (clear).

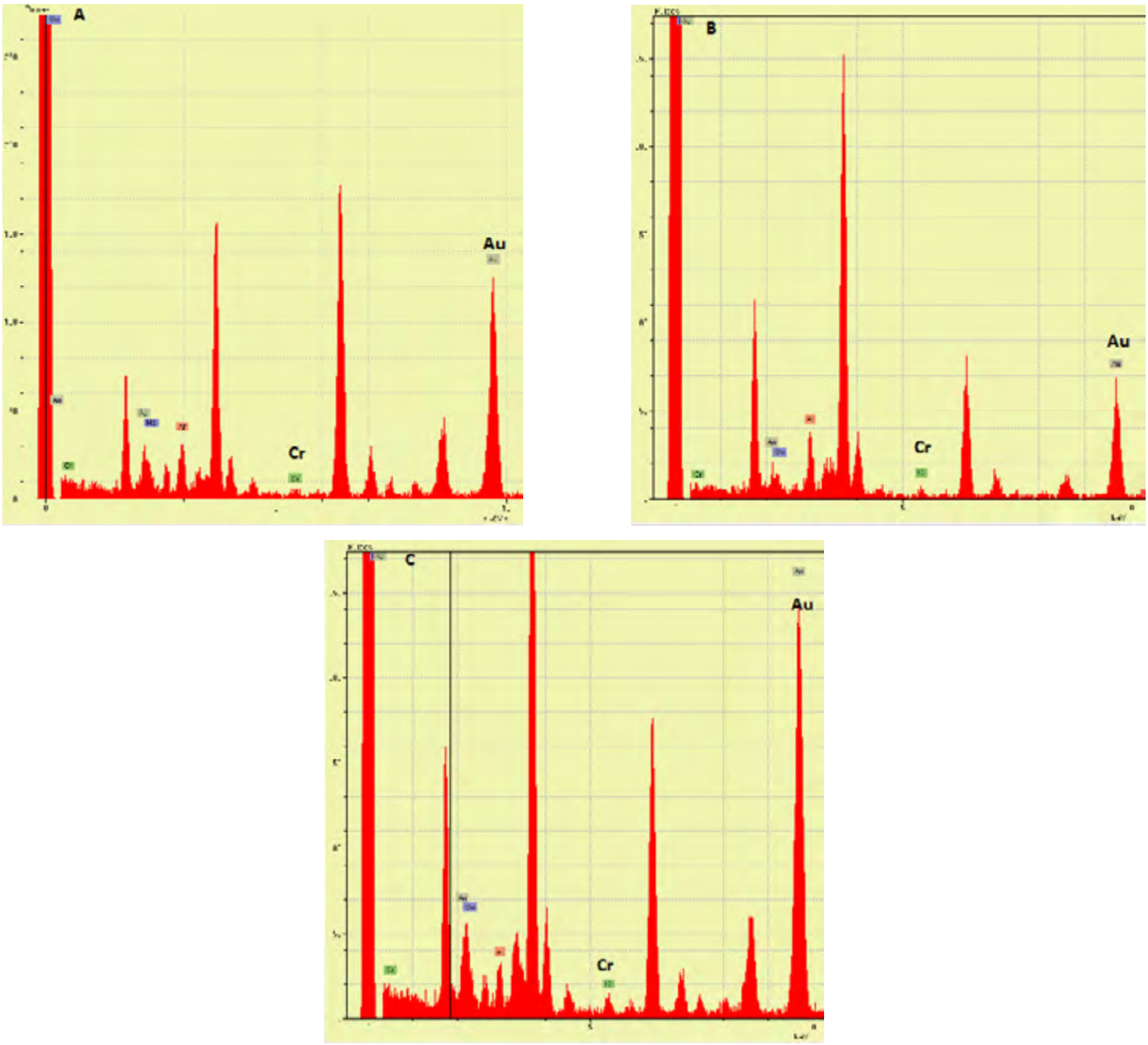

Figure 3. A) Scan of 0 ppb film. B) Scan of 10 ppb soaked film. C) Scan of regenerated 10 ppb film.

An example of ratio differences for this 10 ppb soak would be:

- Pre-soak: Cr/Au = .0026
- Soak: Cr/Au = .2157
- Regeneration: Cr/Au = .1178

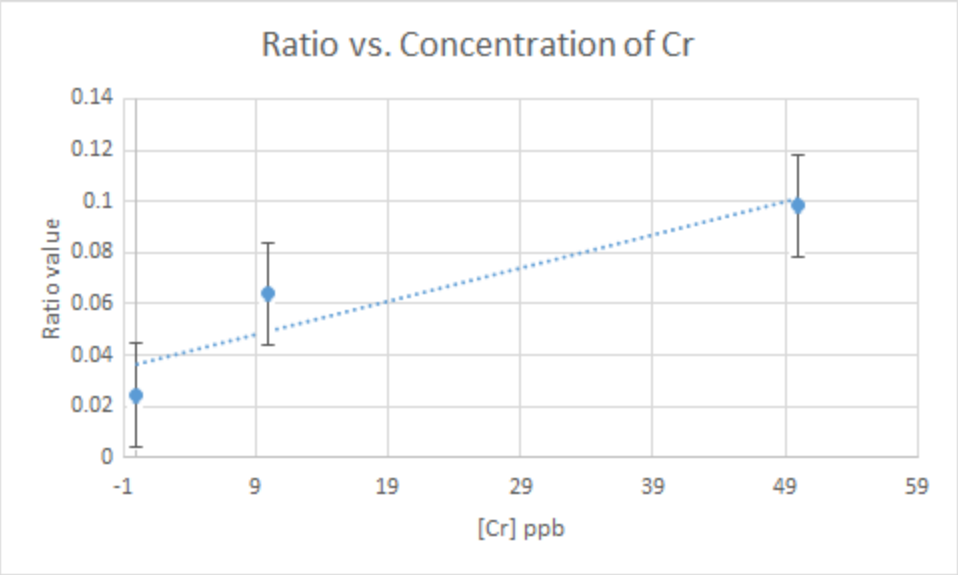

Figure 4. Partial calibration plot of ratio of Au and Cr(VI) concentrations with confidence interval error bars of 95%.

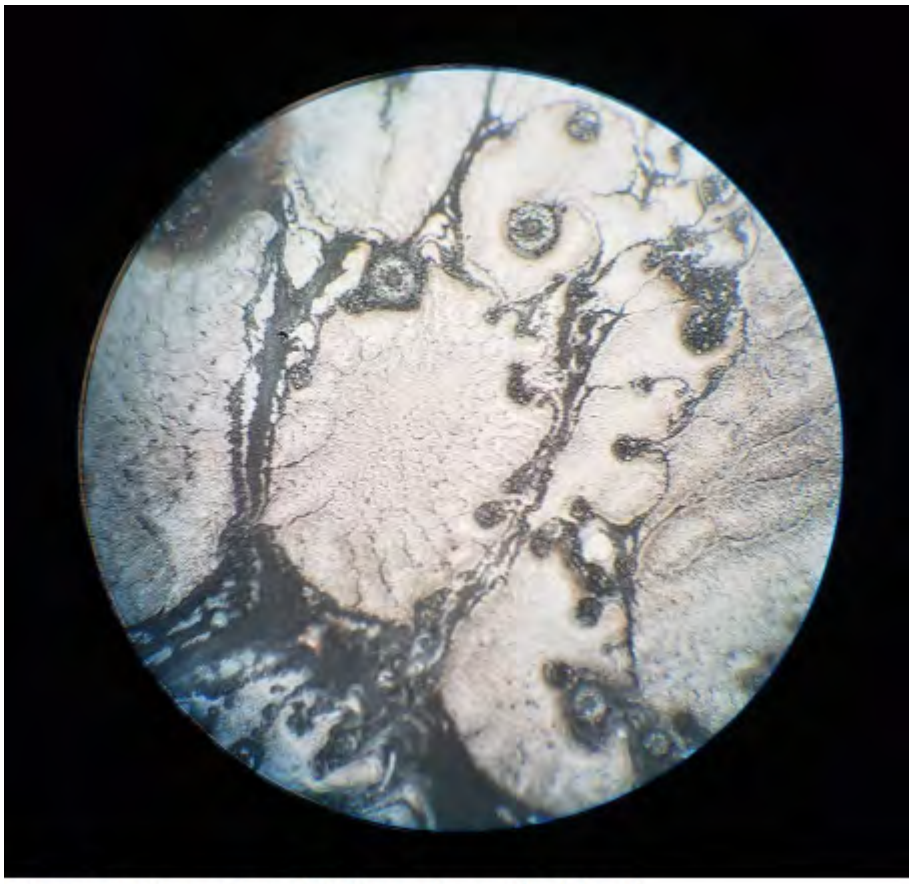

Figure 5. Dispersion of PVP on glass side (black).

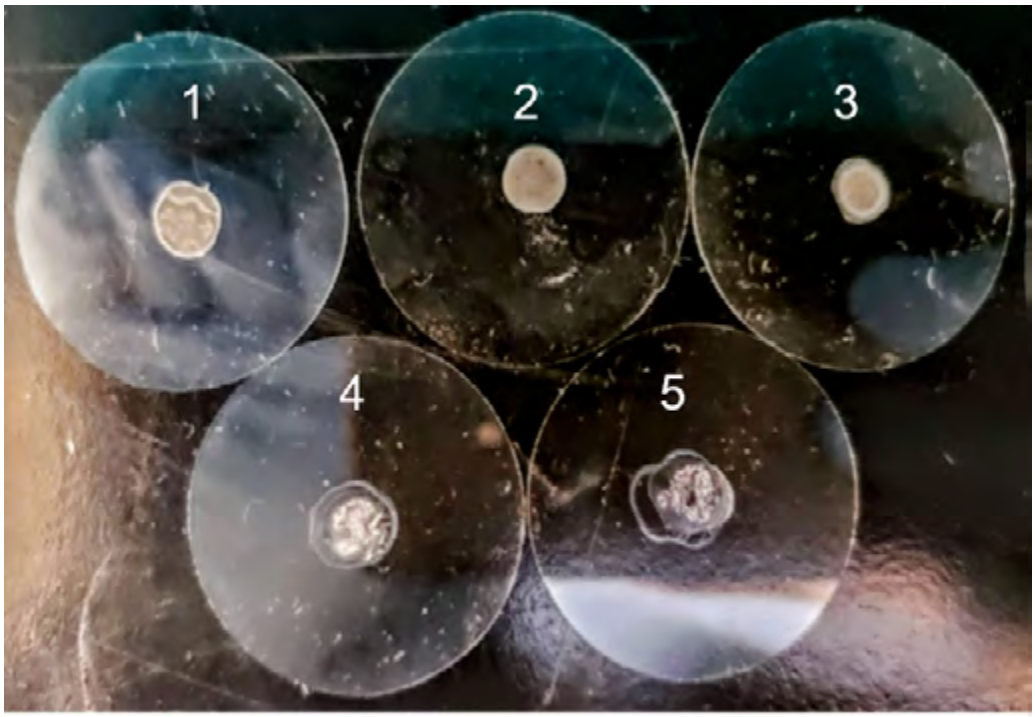

Figure 6. Slides from method comparison (noted by numbers).

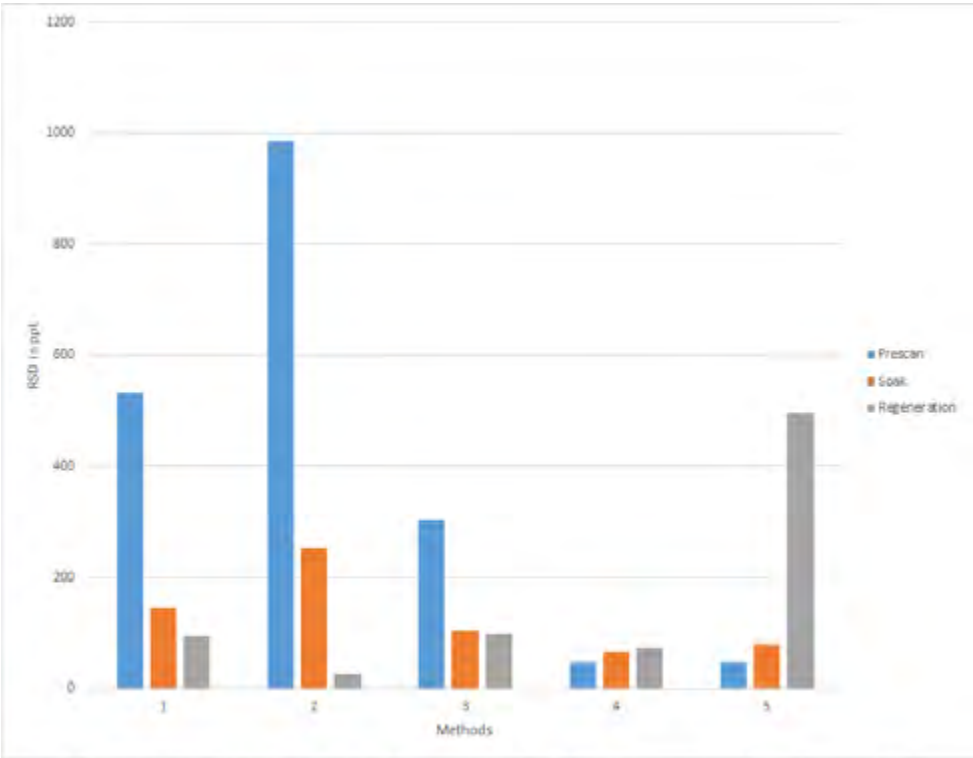

Figure 7. Comparison of RSD in ppt values between methods for the prescan, soak and regeneration steps.

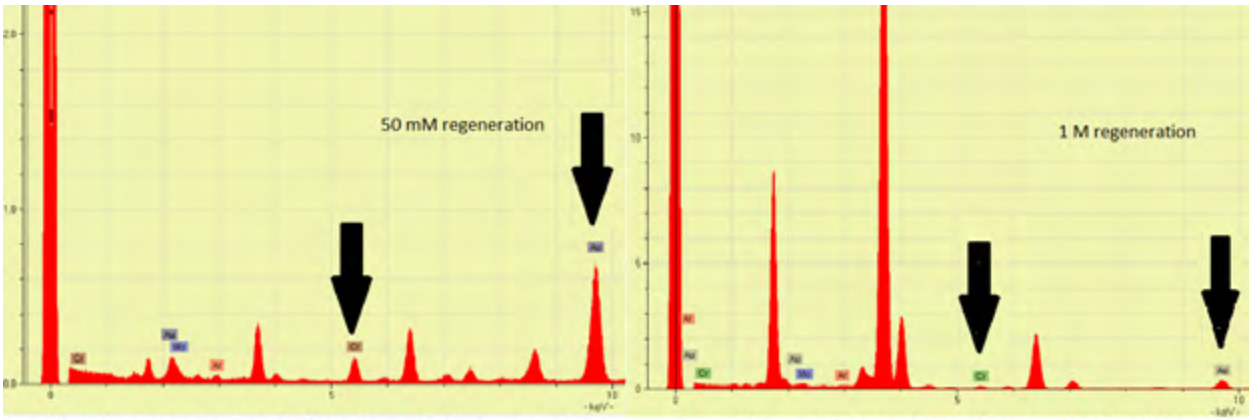

Figure 8. Basic solutions (NaOH) of different concentrations were tested for regeneration viability, but exhibit AuNP internal standard leeching at higher concentrations.

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